

Ṣaṭpada

Our World Of Insects



Rebecca Thomas
Geetha Iyer

Ṣatpada

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RISHI VALLEY EDUCATION CENTRE
Krishnamurti Foundation India

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Foreword

If a student is found looking out of the window rather than listening to the teacher, this would be a bad sign in a maths class but not necessarily so in a biology class! This is especially true in India where biology, which is supposed to be the study of living organisms, has been degraded into the study of preserved, dead specimens under the best of conditions, and into the study of caricatures drawn with a chalk on the blackboard in the worst of conditions. This has to change. At least half the biology classes in all our schools and colleges should be held not in the confines of the classroom but out in nature, in gardens, on the roadside, in open scrubland, in the forest, on the banks of streams and lakes, anywhere in the outdoors. Here the teachers and students should together learn to locate, identify, observe and develop a relationship with worms and insects, butterflies and wasps, frogs and snakes, birds and bats, herbs and shrubs, lichen and fungi, trees, flowers and fruits...

This method of teaching and learning will inspire both student and teacher to explore nature and take to the study of biology and will make them better educationists and scientists, better citizens and human beings. There is little doubt in my mind that it will not only give a fillip to areas of organismal biology such as ecology, behaviour and evolution but will also provide a strong foundation to those students who wish to pursue more reductionist areas of biology such as genetics and molecular biology. I am therefore confident that it will spawn a new generation of internationally competent researchers in all areas of life sciences and will spell the beginning of the end of the era in which Indian scientists largely play second fiddle to the developed world and generally pursue a rather insignificant and imitative research agenda. But such a revolutionary change in the philosophy of biology education is not easy to usher in. It requires a major change in the mindset of administrators, teachers, students and parents. Hard as these are to achieve, I am aware that even they are not enough. We need the technical means to do so - we need knowledge and books about life in our own outdoors and backyards and roadsides and believe me, we

rarely have them. In a country as biologically diverse as India, it is not enough to have a general knowledge of the plants and animals of our country and guide books about insects or birds of India, of Andhra Pradesh or even the of Western Ghats. We need very specific knowledge of local flora and fauna and guide books written by experts who have firsthand knowledge of our backyards.

How can this be made possible? Who will spend their time acquiring firsthand knowledge of our backyards and write guide books for us? In an ideal world the students and teachers of each school must turn their biology classes into outdoor research laboratories to personally acquire a deep and authentic knowledge of the biology of their backyards and write their own guide books. But as the cliché goes, we don't live in an ideal world. Nevertheless, there may be a ray of hope. I believe that The Rishi Valley School comes as close as we might get to the ideal world I described above. I have had the personal pleasure of meeting the administration, teachers and students and indeed the biodiversity of Rishi Valley School. Here it is possible - you have all the required ingredients - a rich and interesting backyard, amazing students (who live on the grounds and can therefore watch ants and bees even while brushing their teeth!), committed teachers and an enlightened administration.

The present book "Śatpada Our World Of Insects" by Rebecca Thomas and Geetha Iyer is a direct consequence of the rare coming together of all these unusual ingredients. The book truly provides a glimpse into the world of insects in a simple, friendly and colourful way. Perhaps the most promising part is Part III, which has a section entitled "Entomology as a pastime" and also contains tips for student activities, and checklists of insects and plants in the school's grounds. I hope that the book will be inexpensive, will be read and used widely and become a success. And by success I mean that the book should inspire teachers and students of Rishi Valley School to teach biology outdoors and to produce in the next five years, a field guide to the insects of Rishi Valley on the lines of "Birds of Rishi Valley and Regeneration of their Habitats" published in 1994. I am sure your success will spawn similar efforts in many other schools. So here's your challenge and I wish you all the very best.

— Prof. Raghavendra Gadagkar
Centre for Ecological Sciences and Centre for Contemporary Studies
Indian Institute of Science, Bangalore

Preface

‘Guess what? The hornets are building again! How do we save the nest this time?’ questioned Krishnan, then in class 12, the gleam of discovery and the anxiety of a possible loss simultaneously reflecting in his eyes... and thus began a journey into the world of insects , a journey that was so fascinating that it soon had a large number of adults and children on the bandwagon. As adults witnessing the enthusiasm of children and their lookouts, discoveries, queries, collections, sensitive responses and wonderous sighs, we were prompted to bring out a book on insects.

This is not the work of trained entomologists, but of two biology teachers who, along with their students were attracted to the insect diversity that existed in the campus of Rishi Valley. Insects became the subject of study in many different ways, and soon they were instrumental in heightening the awareness in children and adults alike, of the need to conserve the environment. Often its the fear and not their beauty that seem to bring insects into our sphere of attention. The loss of our wellbeing is so etched in our consciousness as also the thought that insects can only harm that, more often than not the uniqueness of their appearance or lifestyle seem lost on humans.

But for many at Rishi Valley, insects could appear on a different level altogether — as beautiful and colourful as birds, as challenging as snakes, as diverse as the flowers that draw our attention, as engaging as a spy-thriller movie and finally as creatures that both kindled the curiosity of some and frightened the life out of others. Why else would a bunch of active, cricket- crazy boys agree to suspend their game in their favourite place for a full term and let the hornets build their nests? Why else would a twelve year old donate his towel so that the eggs of a moth could remain undisturbed and hatch ? Why else would a principal of a school carefully lift a dying insect and leave it in the care of a teacher? Why else would eight and nine year olds walk carefully so that they do not step over the

ants as they shifted their colony, or spend endless hours watching an ant save itself from an antlion nest (or be consumed by the antlion larva)? Insects, seemed to have a special place in our consciousness and life at Rishi Valley.

Insects are too many and too varied to be dealt within a few pages of a book. Our intention in writing this book was twofold. First, to bring about a different viewpoint in addressing insect life — to move away from the dull and drab stereotypical, biology classroom approach of harmful and useful insects (as it always is featured in a school textbook); second to provide a resource for teachers and students of environment studies— a tool that will help them understand the concepts related to environment education. We have tried to address these two issues through a series of descriptions and activities. It is by no means thorough, but if it enthruses someone to undertake a detailed study of insects or to be able to look at insects without an instinctive recoiling, our aim would have been fulfilled.

— Rebecca Thomas and Geetha Iyer

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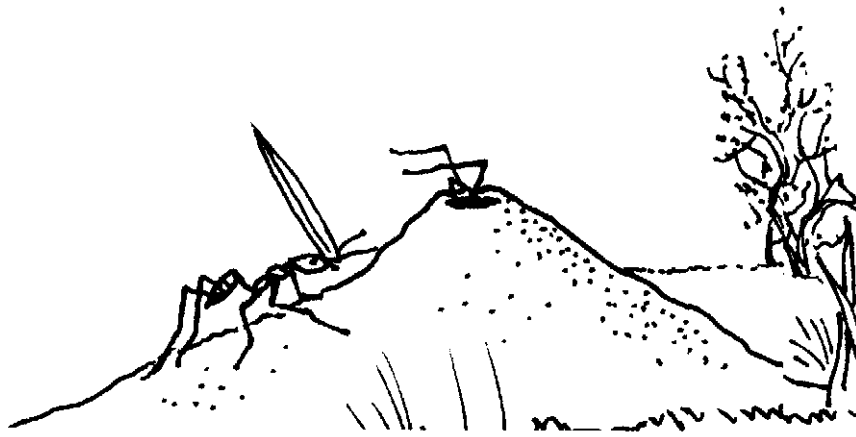
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INTRODUCTION

The material found in this book has evolved out of the fieldwork undertaken by us along with our students at Rishi Valley, a residential school where people live close to nature. 'RV', as it is fondly referred to by its students, is essentially a scrubland with dry deciduous vegetation. A valley surrounded by ancient rocks of volcanic origin, water can often be a scarce commodity here. This is essentially a drought-prone area of the Eastern ghats. Therefore the community of people living at Rishi Valley have made conscious efforts to conserve water. This has resulted in a series of percolation tanks, check dams and relentless efforts at reforestation of the hills. Thus although a scrub jungle is what one sees, there are wetlands, small wooded areas on the hillside, and grassy patches — habitats in which insect diversity thrives. If insects thrive, then, naturally, so will other members of the living world, as insects form such an important link in the food web. One of the major requirements in today's world is habitat conservation, allowing for species diversity to if not flourish, at least to prevent their slow extinction. The process of regeneration is an important aspect of life at Rishi Valley.

The field study started in the early nineties and between then and now, Rishi Valley has gone through its cyclic periods of drought, of late, more serious than the previous years which no doubt has effected a change in the insect profile and the ecosystem of the place. However with some rainfall that has come in subsequently and the water conservation efforts undertaken by the school, it has been noticed that certain insect diversity has returned. In a way the reappearance of some insects and the continued presence of many others is a statement of the resilience of these animals and a lesson in survival. Insect diversity in this place is marvellous. This book, we hope, will serve as a guide for teachers or students interested in insects, ecology or the environment. We are yet to catalogue all of the insects found here, for that is an ever-continuous process. We hope that this book may interest some to take up the study of insects whose diversity is simply remarkable.

PART ONE

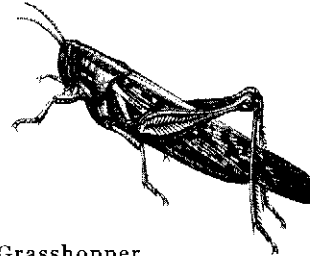


Ants easily outlasted the dinosaurs, and they will outlast humanity should we stumble.

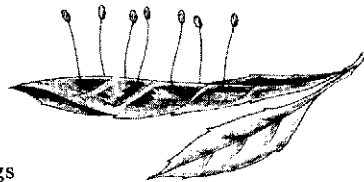
— E.O. Wilson
The Diversity of Life

1. Why Study Insects?

Insects form the largest group of animals and makes up almost 75% of the animal kingdom. In terms of numbers and diversity, insects are the acknowledged winners of in the animal kingdom. They occupy every available niche on the earth's surface barring the sea, because of their inability to tolerate the high salt content of the seas. The Latin word *insecta* means 'notched' because of the characteristic indentation in the body which separates the posterior 'abdomen' from the more anterior "thorax". However this is a very generalised description and is also the reason for a number of unrelated creatures quite often being dubbed as 'insects'.



Grasshopper

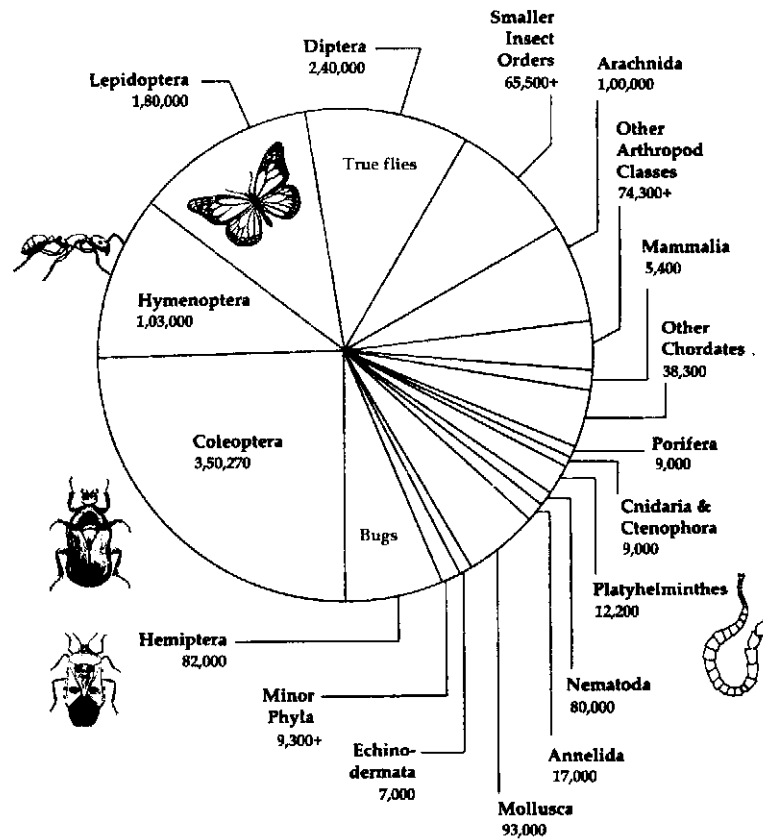


Eggs of lacewings



Mantis egg case

But insects are interesting in a strange way— strange because they do not subscribe to those features we are familiar with or take for granted. The skeletons of all insects are outside their bodies some insects smell with their long feelers; others hear with their legs for the ears are placed in their knees, legs (or sometimes in their abdomen); they have no vocal cord yet speak (produce sounds) by rubbing one part of their body with another; the salivary glands in the caterpillars of some moths produce silk; and the hind wings have become balancing organs in flies. They are so amazing at adaptation that their body parts have transformed according to their needs for survival. So, how do they do this?



Biodiversity density compared

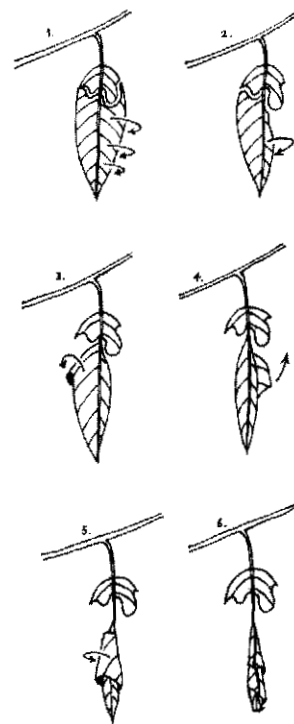
The unmatched ability of insects to adapt to a variety of living conditions has gained them an entrance to the most diverse habitats. It is a remarkable feature that they can live anywhere on the earth: under the soil, inside caves, inside other organisms, within the crevices of, or high up in, trees. They owe their success to a number of important features, some of which we list below. (You will find these features in greater detail in the chapters that follow.) As they evolved over the last 400 million years they have managed to survive where other forms of life have perished. This is due to adaptive strategies unique to the insect world. Some of these are:

- their body size which ranges from minute (soil beetles and small body lice) to large (moths and the massive Goliath beetle);

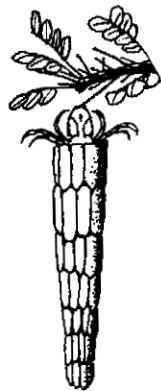
- their feeding mechanisms—be it on diets liquid or solid, soft or hard, rotting or fresh, blood or water;
- their diverse reproductive strategies to the extent of varying their gender based on environmental parameters.

Similarly, several other physiological features contribute to their success. These include a tracheal system of respiration, haemocoel, a flight mechanism with a unique wing design and function, and the success achieved in reproduction and development.

Last but not least is the biological interest these creatures have evoked. Their beneficial as well as their destructive roles have always been highlighted. What has not been given the same attention is the ecological role played by insects in maintaining the balance of life and holding the fragile web of life together.



leaf roller



Bagworm larva in its case

The Ecological Significance of Insects

Ecology is a branch of biology that studies the relationship between living worlds and their non-living habitats. These studies are undertaken with the central focus being either individual organisms, or populations and communities. Autecology, which is not as popular as community ecology, has individual organisms as the focal point. This branch of biology along with ethology has brought to light several fascinating facets of hitherto unknown organisms, the behavioural quirks of known ones, and the survival tactics adopted by many. Several such studies by autecologists have increasingly brought to light the role of insects as 'ecological guardians', the most notable one being the study of Ants by Bert Hölldobler and E.O. Wilson.

Closer home there have been several entomologists who have looked at the ecological importance of insects. The work done by Prof Raghavendra Gadagkar with wasps is noteworthy.

Despite this, insect ecology still seems to be in the hand of agricultural entomologists, confined to the narrow realms of a limited anthropocentric view point. There is a larger role that insects perform. It is only recently that they have begun to be seen differently, but even then their ecological significance receives limited or no recognition

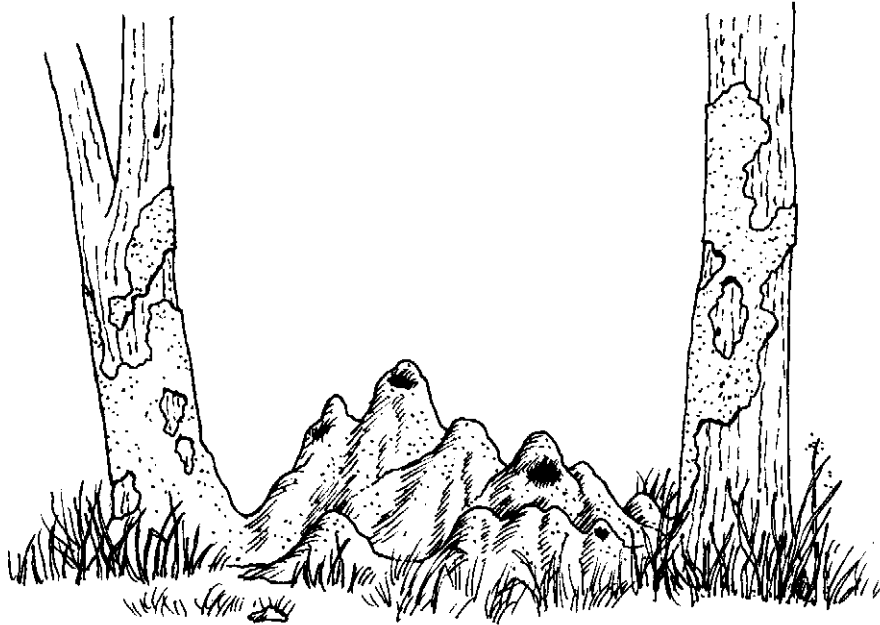
This is what the renowned myremecologist E.O. Wilson has to say of insects

So important are insects and other land dwelling arthropods that if all were to disappear humanity probably could not last more than a few months. Most of the amphibians, reptiles birds and mammals would crash to extinction about the same time. Next would go the bulk of flowering plants and with them the physical structure of most forests and other terrestrial habitats. Land surface would literally rot. As dead vegetation piled up and dried and closing channels of nutrient cycles. Other complex forms of vegetation would die off and with them all but a few remnants of land vertebrates. The free living fungi after enjoying a population explosion of stupendous proportions would decline precipitiously and most species would perish. The land would return to approximately its condition in early Paleozoic times.

They create and conserve habitats.

Organisms while deriving sustenance from their habitats also create for themselves a certain environment most favourable for their survival. Every organism performs this function. Trees draw nutrients from the soil, but also shed their leaves for decomposing organisms to recycle. What do insects do? They do very many things. They create houses—termite homes are not just for themselves but also for others, like reptiles, ants, etc. They turn the soil, dig it, eat the decaying vegetation and thereby create fertile soils as good as the soil worked on by earthworms. They feed on other organisms, helping to keep a check on the population of other insects. Thus insects are like other animals, plants or humans—constantly adding or removing materials from their habitat in their attempt to improve their chances not merely for survival but also for

procreation. Insects do it in a manner that, by virtue of their diversity and presence in all habitats, has a great significance to the Earth and the life it holds.



Termites at work

Insects have a lot of interaction not only amongst and between them, but also with the widest range of organisms—from the simplest of viruses, bacteria, fungi, plants, to other animals. These interactions shape and mould, and bring twists and turns into the biosphere which is indicative of significant ecological potential. The scientific community is increasingly coming up with evidence of the positive ecological impact of insects, but even as a layman, one can observe in nature some of these processes.

Insect-Plant Interaction

More than 50% of the insect species being herbivorous, their relationship with plants is a remarkable example of a single type of biological interaction on this earth.

Feeding on the aerial parts of plants requires specialization and also the ability to overcome dehydration. And as these insect communities perfected their adaptations, so did the plants to ensure that they are not so readily and easily

available to them. An evolutionary scientist would perhaps find that there must have ensued, what we can call in modern day parlance, an 'arms race' between plants and insects as one tried to outsmart the other in their efforts to survive. The variety of aromatic compounds plants possess were (at least in some cases) probably the chemical weapons secreted to combat the onslaught of insects. What a boon it is. The pharmaceutical companies, the cosmetic industry, and coffee and tea drinkers owe a salute to the insect; without them plants may not have produced such a variety of chemicals!

Describing the secretions as simply arsenals for chemical warfare would be being very unfair to insects. Plants have adapted well to take advantage of insect-plant interactions. Some plants secrete chemicals because they want to attract insects—to use them as food as in several genera of insectivorous plants (sundew, bladderwort, etc.) or else to use them as pollinators. For example, there are some pitcher plants that allow the larvae of flies to live unharmed on their digestive juices. These larvae feed on the mixture of water-decaying insects and provide the plants with nutrients, saving them the job of even digesting the insects. Insects are efficient pollinators, a vast majority of the world's quarter of a million or so species of flowering plants depend on them. So good are they in this process, so vital it is for the survival of the plants that the fascinating pollination biology is a subject for specialized study. Both the benefactor and beneficiary have evolved wonderful and sometimes spectacular features to make pollination a successful venture. In the case of the fig tree-wasp relationship lies a story of the survival of two species so very closely dependent on each other that the interaction has remained exclusive. Figs cannot be pollinated by any insect other than a particular species of wasp and then these wasps can reproduce nowhere else except within the fig! This is an example for understanding the term 'niche'.

Insect and Others of the Animal World

Insects are of importance to the survival and maintenance of several ecosystems in the world. Without insects several higher order of species would simply not exist at all! The anteaters are superspecialised to feed exclusively on a diet of ants. The ants in turn cater to the needs of termites, another insect group. That there is a group of birds that are known as 'insectivorous birds' is a facet of insect evolution.

There are insectivorous birds, reptiles and mammals. In Rishi Valley as in several other places in the Southern Peninsula of India, bee-eaters and drongos are quite common! One can spend the entire evening watching the acrobatic behaviour of the drongo as it preys upon insects in mid-air! The beaks of the bee-eaters are specialised to prise out the bees from their hives!

The spiny anteater, as the name itself suggests, is specialized to feed exclusively on ants! It is a measure of their success that despite being a prey to a host of animals, herbivorous insects are still able to maintain populations that can cause heavy harm to agriculture crops and other plants.

The larvae of beetles and butterflies are a rich food source for animals. Chimps love to gorge themselves on termite queens. Small birds such as tits, or even seed-eaters, like buntings, feed their young ones with caterpillars or on a nutritious diet of insects.

Despite a large number of animals, plants and humans feeding on them, and the innumerable control measures adopted by us, insects have not failed to proliferate.

Architects and Farmers

To a common man termites are pests eating away his furniture, destroying his woodwork etc; but this lifestyle of searching for dead wood on which to feed has a tremendous impact on many habitats. In Rishi Valley as the month moves from February to March, one can see brown patches appear and begin to move from the base up the trunk of trees. The brown patches snaking their way upwards are termite houses made by termites as they feed on the dead bark. They save trees from other insect predators which look to the barks of trees for their homes. They may attack the live tree, but at the same time they also recycle the dead wood back to the soil!

Termites can consume upto one-third of the annual production of dead wood, leaves and grass. They are present in numbers unimaginably large, sometimes exceeding 800/ft².



Inside a termite mound

Although very small in size, their total biomass per unit area can vary from $1\text{-}5\text{ g/m}^2$ to 22 g/m^2 . Rishi Valley can easily recycle its newspapers in a compost pit thanks to these termites. Their ability to digest cellulose is largely due to the symbiotic association with bacteria and protists in their guts and through cultivating symbiotic fungus in their nests. All termites, except the fungus-growing ones, use bacteria for cellulose digestion.

The termite mounds of Rishi Valley, though not reaching such spectacular heights as seen in Africa, are reasonably diverse; in different shapes and sizes they provide shelter for snakes and rodents. In certain cases animals seem to compete to have the cool air-conditioned interiors of the termite nests as homes for themselves. Although termites are prey to some species of ants, they have symbiotic relationships with others. We have observed at Rishi Valley that some ants defended the termatariums, perhaps in return for shelter and food. Several questions spring to one's mind as one looks deeper into the termites' lives: How did they manage to evolve these architectural wonders so full of chimneys and tunnels that lead to an air-cooled interior? Is there a lesson here that can be learnt by our modern-day architects so steeped as they are in a cement and mortar culture? In human societies, where a caste system is seen as a barrier to leading a qualitative life, what evolutionary advantage has the termites discovered? But from a sociological viewpoint, is it an advantage for organisms that are social/live in social groups?



The dung-beetle

When one says, 'beetle', the very name makes a person recoil in disgust. Yet they are, from an ecological point, a group that have a significant impact on the earth.

Laboriously rolling the soil and the dung together, the dung-beetles quietly give back valuable nutrients to the soil. And what's more, they have been doing this for a very long time; fossil evidence is available of these dung beetles working away on herbivorous dinosaur dung! Eggs are laid in dung, so that the larvae that emerge have a ready-made food source. Their importance as recyclers cannot be belittled. In Australia, the introduction of cattle that are not native to the area caused enormous problems! The

dung-beetles that existed locally could not handle the large quantities of dung, excreted by the introduced-cattle and, so, finally a large number of European and African species of dung-beetle had to be introduced to recycle the dung! Dung-beetles come in different shapes and sizes. Look for them in the soil. They are not always big; they are quite diverse and can be seen in places which are not manicured by pesticides and fertilizers.

Ladybird-beetles have been extolled in verse, become part of folk tales, and depicted as symbols of happiness and health. *Epilachna* are predacious beetles which are phytophagous, and serve to keep the pest population in check.

This might sound very human-centric, yet it is true that insects, for their survival, do everything that humans do but without the aid of any machines or apparatus, but by simply modifying their own body parts or by using the natural materials around them. They build air-conditioned chambers (termites), use underwater-breathing apparatus (waterboatmen), construct acoustic equipment (grasshoppers, moths, cicadas, crickets), cause explosions (bombardier beetles), make paper (wasps and hornets), take slaves to cultivate gardens or farm other animals (ants). They have extraordinary relationships with other animals. There are moths that suck mammalian blood, flies whose larvae develop only in the tracheal passage of kangaroos, and lice that inhabit the throat pouches of certain cormorants and pelicans.



Water-scorpion

Insect-Insect interaction

Insects have evolved to occupy many more ecological niches than large organisms could ever manage. Insects have managed to live even between the tissues of leaves, in the narrow spaces between the upper and lower epidermis as in the case of leaf-miners. The interaction between different insects is quite interesting.

Insect-insect interactions are quite fascinating as insects perform vital ecological roles through these relationships. For example they keep a check on each other's populations, provide food for and protect one another.

Wasps and mantids prey upon insects and insect larvae. Wasps use insects as food for their larvae. Mud wasps paralyse caterpillars, spiders and other insects and store them in the nests in which they lay their eggs. When the eggs hatch into larvae, these insects serve the larvae with the nutrients they need in order to develop into adulthood.

The adult mantids are carnivorous and prey upon insects for food.

How Do We Conserve Insects?

This is a more difficult question because at a basic, functional level the conditions for survival are different for each insect species. In order to conserve insects we need to make sure that everything they need to live is available for them and at those time when they need it. This is quite a difficult task to ensure, because many insects use one habitat as a food source in the juvenile form, another for a food source as an adult while maturing, yet another for meeting mates and laying eggs and perhaps still another as a place to spend while wintering.

Unfortunately, we do not know of all the various requirements that are needed by many insects. 'Insect Conservation' therefore involves 'Habitat Conservation'. This works on the hope that if we preserve enough of each type of habitat it will allow the dependent insects to survive. As there are a million known species of insect on the planet, and perhaps as many as 30 million yet to be discovered, we will need to have a lot of data on the species of insects that are alive and their requirements if we wish to conserve them. This is a task easier said than done.

Biodiversity Conservation is an important buzzword in many political circles these days and it is a fact, though many would not agree, that 'Biodiversity Conservation' is in fact 'Insect Conservation'. The big problem though is how to convince politicians, businessmen and bureaucrats that this is important.

There are many examples and much more that can be said about insect conservation; if you are convinced that it is important then you can be a part of habitat conservation. You may want to read more books to learn more. Some you should be able to find in your local library, others are definitely worth buying.



2. Biology Of Insects - A Brief Overview

Insects along with crustaceans (prawns, crabs, and lobsters), arachnids (spiders, ticks, scorpions and mites) and myriapods (centipedes and millipedes) constitute the phylum Arthropoda, which is characterised by

- A segmented body covered with chitinous exoskeletal plates
- Jointed appendages
- Compound eyes

Insects can be distinguished from other members of arthropods by observing whether the following features are present:

- Body divided into three regions, viz. head, thorax and abdomen; head bears a pair of compound eyes, ocellus/ocelli, a pair of antennae variously shaped, and chitinous mouth parts adapted to their feeding habits.
- Thorax made of three segments, each segment ventrally bearing a pair of jointed legs, and where present a pair of wings each on the second and third thoracic segments
- Abdomen consisting of 4-10 segments, with the last segment bearing genitalia and the sensory cerci.



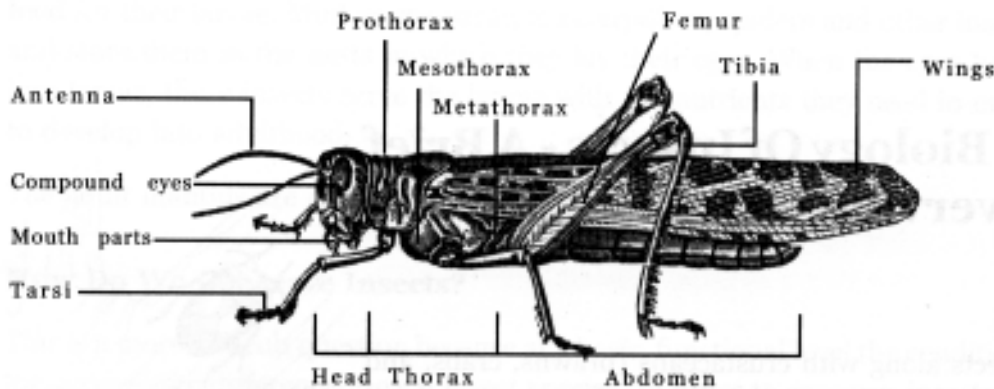
Bug



Beetle



Hornet and it's nest



External features of an insect

- If you carefully observe an insect on its lateral ends, you will notice a pair of pores laterally on each thoracic segment, extending posteriorly towards the tip of the abdomen, which are spiracles, the openings of the tracheal system, which takes air directly to the tissues, unique only to insects.

Because the majority of insects are small, ranging in size from 6 mm to 16 cms, and some even microscopic, it is natural for a layman to mistake any small creature for an insect. Thus from an earthworm to a mite, spider or a tick seen on dogs, a variety of creatures are mistakenly labelled as 'insects'. The features listed above should serve as an easy guide to identify them correctly. For a greater understanding, the figures given are those of beings that are NOT INSECTS but which are often mistaken for one.

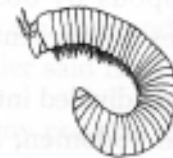
In order to understand the existence of such diversity in the insect world, one needs to know a little about the body parts of the insect and the way the parts are arranged. So here is a brief description of what the biologists call the external morphology of insects.



a



b



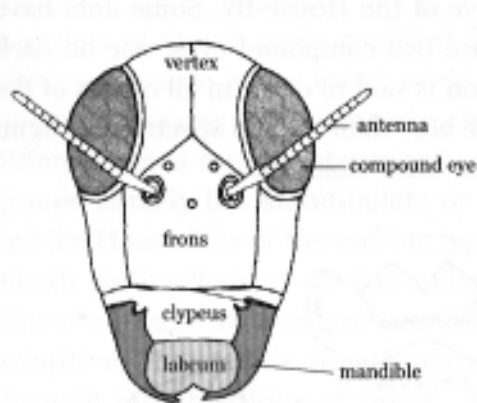
c



d

Arthropods
that are not insects
a Crustacea
b-c Myriapoda
d Arachnida

The insect body is divided into three regions, namely, the Head, Thorax and Abdomen. As mentioned above, since the entire body of an insect is segmented, the head, too, is no exception. The segmented head bears organs for feeding, sensory perception, and neural integration.



Mouth parts

The head consists of the antennae (feelers), eyes and mouth parts. The antennae and the mouth parts show great variation. The antennae are variously shaped and sometimes differ on the male and female of the species. Their structure is unique to different groups (orders) of insects, and is one of the key characters in identification. They are mainly concerned with the sense of smell and touch. The figures on the right will give you an idea of their shapes. The antennae are also jointed in nature.

There are two types of eyes. The simple eyes or ocelli and the compound eyes. The ocelli are simple, light-receptive cells, usually three in number and are found between the bases of the antennae. Some insects, such as mosquitoes, do not have ocelli. Compound eyes, the main visual organs are so called because they are made up of a number of individual lenses—

Cockroach



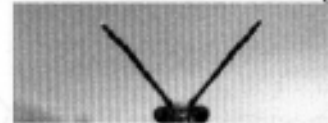
Butterfly



Moth



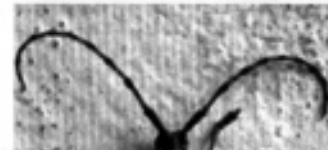
Bug



Ant



Beetle

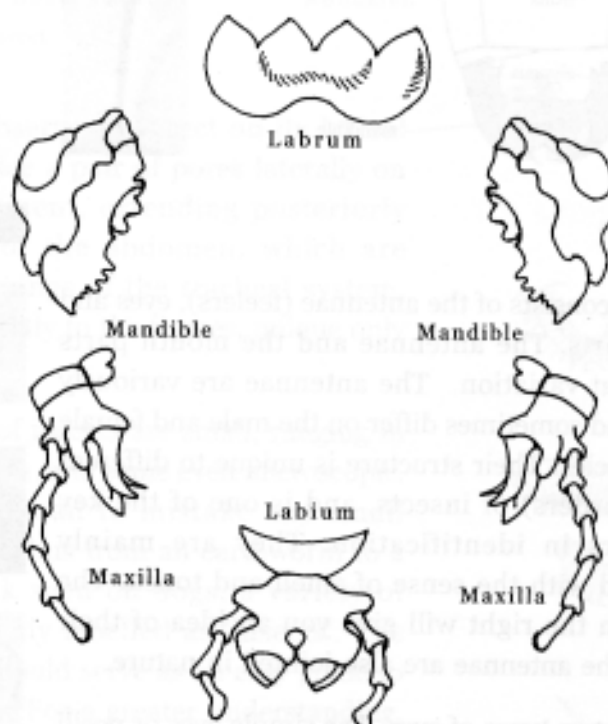


Beetle



Shapes of antennae

ommatidia—arranged together in a honeycomb like fashion into a single unit. Each of these lens is hexagonal in shape. The number of individual lenses varies in different families. A D. Imms in his book *Insect Natural History* (1947) has said that there are 4,000 lenses in each compound eye of the House-fly. Some ants have not more than two. There are two compound eyes, one on each side of the head. Colour vision is said to occur in all orders of the insects, they are better at the blue than the red spectrum of light. Some carry sensitivity for the ultra violet too.



Mouth parts
separated

The mouth parts are another significant adaptation contributing to the success of insects as the dominant denizens of the animal world.

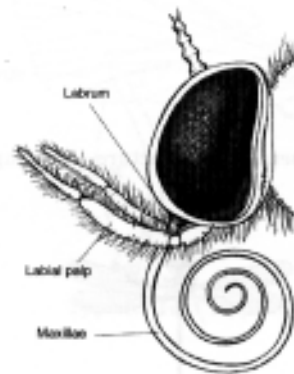
Just as there is diversity in insect form and structure so, too is there a diversity in insect mouth parts. Except for the mandibles and labium, other mouth parts are jointed appendages. The basic plan of the mouth, and its parts, is shown on pages 18 and 19.

The mouth parts comprise of:

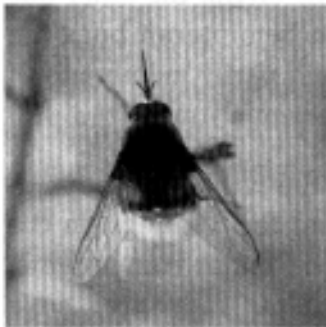
The 'upper lip' or labrum; two 'jaw-like structures', or mandibles; the maxillae (sing. maxilla) and the 'lower lip', or labium.

A variety of mouth parts modified from the basic plan can be seen in the insect world. There are the sucking, chewing, the biting etc., but all of these different kinds can be categorized under two main groups namely the Mandibulate or the chewing—and the Haustellate or the sucking type. Mandibulate mouth parts adhere to the basic plan shown in the figure on page 18 and are considered the most primitive. Haustellate mouth parts have evolved through modifications of these. Thus there are sucking mouth parts of the kind seen in mosquitoes and flies where there is a stylet, and the kind seen in butterflies and moths which do not have any stylets. It is this knack for adaptation of a flexible blueprint of original parts that have made insects such successful survivors.

Mouth parts seen in insects



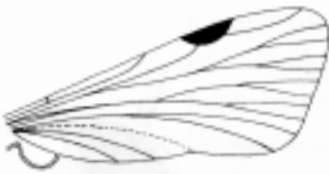
Mouth parts of a butterfly



Mouth parts of a fly



Mouth parts of a mosquito



Generalized structure of wing



Membranous wings of dragonfly



Wing & haltere in a fly



Wings in a bug & haltere in a fly

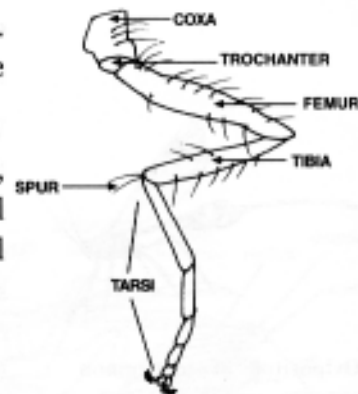
The thorax bears the organs of locomotion. From anterior to posterior the three segments of the thorax are called prothorax, mesothorax and metathorax. Wings are attached to the meso and the metathorax only. The inner wings are hindwings protected by the outer forewings. Some insects do not have wings at all, while others have only one pair—such as the flies. All the three thoracic segments have a pair of jointed appendages called legs. The primary presence or absence of wings is the key criteria in insect classification. The vein pattern on the wings are important when identifying insects to the level of the species. Both the legs and the wings have undergone modifications to suit the lifestyle of the insect. The figures on the left give you an indication of the diverse nature of the things of insects.

Membranous wings are thin and more or less transparent. This type of wing is found among the Odonata and Neuroptera. Halteres are modification among the order Diptera (true flies), in which the hind-wings are reduced to a small protrusion and used for balance during flight. In beetles the outer wing is hardened to form the elytra, the inner one being membranous, and in hemipteran bugs the forewings are partly hard and partly membranous, the wing then described as 'hemelytra'.

The forelegs are located on the prothorax, the mid-legs on the mesothorax, and the hindlegs on the metathorax. Each leg has six major components, and from proximal to distal they are: coxa (pl. coxae), trochanter, femur (pl. femora), tibia (pl. tibiae), tarsus (pl. tarsi), pretarsus.

The femur and tibia may be modified with spines. The tarsus appears to be divided into one to five 'pseudosegments' called tarsomeres.

Leg modifications seen amongst insects are termed, Cursorial (Beetle), Raptorial (Mantis), Fossorial (Mole-cricket), Saltatorial (katydid) and Natatorial (Water beetle).



Typicle leg Appendage



Beetle - walking



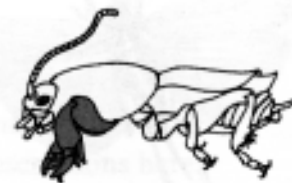
Mantis - grasping



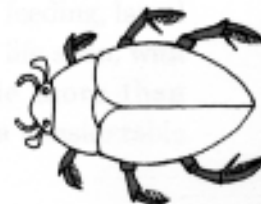
katydid - jumping

There are usually anywhere from 4-10 segments forming the abdomen. The 8th and 9th bear reproductive structures.

The dorsal and ventral abdominal segments are termed terga (singular tergum) and sterna (singular sternum), respectively. Spiracles, openings of the breathing organ trachea are seen on terga, on sterna or between the terga and sterna of abdominal segments 1-8. Sometimes not all abdominal segments may have spiracles. Reproductive structures are located on the 9th segment in males (including the aedeagus, or penis, and often a pair of claspers) and on the 8th and 9th abdominal segments in females (female external genitalia, copulatory openings and ovipositor). The interesting feature in the abdomen is the various modifications of the ovipositor, as for



Mole-cricket - digging



water beetle - swimimng



Ovipositor of ichneumon

eg, in wasps these are the organs that deliver the painful sting!

We have given you a brief account of the external features of insects. If it has caught your attention a more detailed account can be had by reading some of the books given in our bibliography. For a keen student of entomology, the book, *The Insects – Structure and Functions* by R. F. Chapman is an excellent one to learn from.

Looking into an insect's body:

Just as the outside of the insect is so fascinatingly diverse, so is the way its organs are located inside for the metabolic feats. There are some physiological features that are unique to the arthropods which have also contributed to the success of insects. We give you a brief account of some of these features.

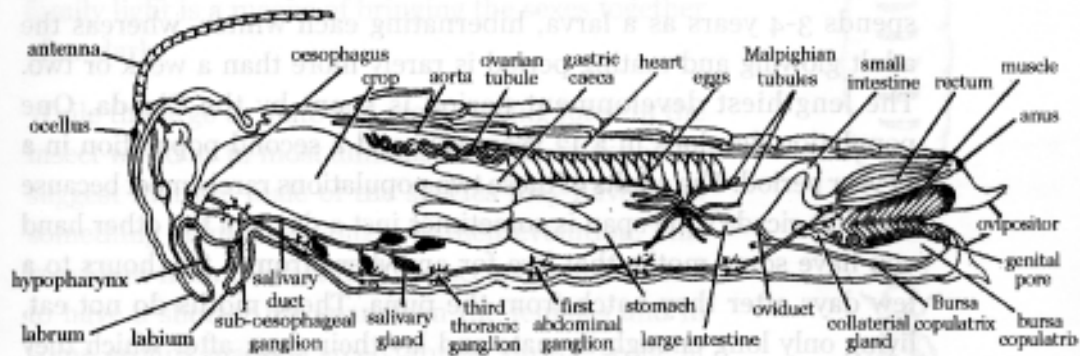


Ovipositor of katydid

Haemocoel: Coelom in biological language is a term that refers to the body cavity of animals. The body cavity holds the visceral organs like the heart, lungs, liver, etc., and in some perform specialized functions.

In insects the digestive canal and all other organs which lie in the body cavity are immersed in blood. (Haemblood). This is because the body cavity has expanded to become associated with the blood system, and there are few true blood vessels.

Insects in this respect seem at first to have a great advantage over vertebrates—the digested food percolates through the walls of the stomach directly into the blood and thus speedily reaches the different organs in the body. In vertebrates it has to pass



Internal organs of a grasshopper

through lymphatic vessels and pass into the general circulation to reach arteries to be transported to different parts. But the disadvantage is that insects cannot therefore grow into large sizes.

Reproductive strategies of insects

The journey of an insect from the time it is conceived till its adulthood or birth is a story of marvel, sometimes strange and bizarre. We have detailed some of these bizarre reproductive styles and developmental quirks in our chapter titled 'Insect Marvels'. We give you some descriptions here.

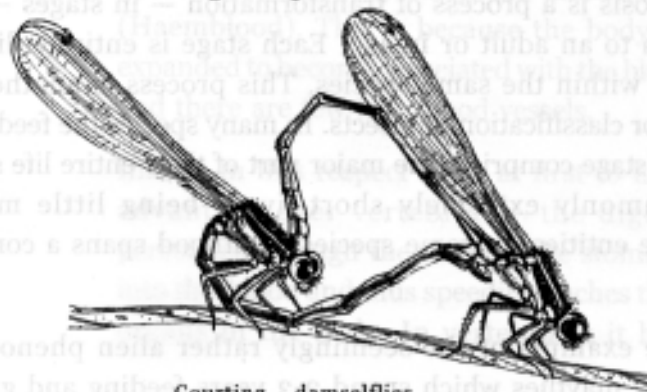
Metamorphosis is a process of transformation — in stages — from an egg through to an adult or imago. Each stage is entirely different in appearance within the same species. This process is another criteria important for classification of insects. In many species the feeding, larval or nymphal stage comprises the major part of their entire life span, with adults commonly extremely short-lived—being little more than reproductive entities. In some species adulthood spans a considerable time.

An extreme example of the seemingly rather alien phenomenon is presented by mayflies which spend 2-3 years feeding and growing as

nymphs at the bottom of a lake or stream and then live only for a day as adults. Many beetles have equally long-lived larvae, among them a few orders of wood-feeding beetles and waste-consuming scarabids, while the adults last just a few months. One species of glow-worm spends 3-4 years as a larva, hibernating each winter, whereas the adult glowing and mating period is rarely more than a week or two. The lengthiest development period is spent by the Cicada. One population develops in a 13 year cycle and a second population in a 17 year period. The adults of these two populations rarely meet because an adult cicada's life span is sometimes just a day. On the other hand you have some moths that live for anywhere from a few hours to a few days after they hatch from the pupa. These moths do not eat, living only long enough to mate and lay their eggs, after which they die.

It is the social insects—the ants, bees and termites which tend to produce the longest lived adults. It is thus one of the paradoxes of insect life that an often extremely lengthy larval development produces adults whose active sexual life is extremely brief in some cases only a few hours. Therefore, insects have devised a wide variety of methods to enable the sexes to find each other with the minimum of effort and expenditure of time.

Courtship: Rapid recognition of a potential sexual partner is of paramount importance and, therefore, sexual dimorphism is manifested in a wide variety of forms. Males are more brilliantly coloured or have strange shapes in order to attract females.



Courting damselflies

Male butterflies exude a female beguiling scent or pheromone.

For fireflies and glow-worms belonging to the beetle family light is a means of bringing the sexes together after dark.

While the urge to mate is a great driving force in the insect world as in most animals, there is evidence to suggest that the male of the species may have been something of an afterthought in their evolution. This is evident from the fact that the accepted males tend to have a shorter life span than the females and in some groups males scarcely appear on the scene at all. Parthenogenesis a unique feature (reproduction by means of unfertilised eggs) occurs in a great many insects from bees, wasps, ants, moths, crickets, most stick insects, aphids, etc.

In social bees, it seems deliberately engineered, since the colony-founding queen has a supply of sperm from the short lived male, but is able to use or withhold it according to the need. Thus, for a greater part of the time, she allows some of the sperm to fertilize her eggs while they are still in the oviduct and thus produces females (workers or new queens), while at other times she closes off her sperm retaining sac, preventing fertilisation of the eggs, which consequently produces only males or drones.

In stick insects, males are rare or non-existent so that parthenogenesis is obligatory and almost an unending sequence of females is produced, each of them capable of reproduction without mating. It is clear, therefore, that the two forms of parthenogenesis in bees and stick insects differ widely. In some cases parthenogenesis alternates with a



Various casts of a termite colony

sexual phase and the whole cycle involves another short cut to reproduction—vivipary or given birth to young ones as in gall wasps and aphids.

The form of asexual reproduction has obvious advantages—no time or energy is wasted in seeking mates and the young can begin to feed and grow straightaway and take the fullest advantage of optimum feeding conditions. (The lack of generic variation is an obvious disadvantage.)

Paedogenesis is an interesting reproductive phenomenon displayed by some insects the ability to eggs or given birth to young before they themselves have attained full adult growth, e.g. primitive springtails, certain gall midges, beetles.

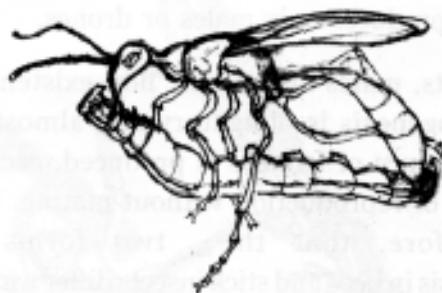
Polyembryony is particularly a characteristic of various parasitic hymenoptera. A single fertilised egg laid within the tissue of a host divides to produce a number of separate embryos.



Caring for young: The ovipositing female displays little or no regard for the future welfare of her young. Apart from positioning the ova where they are less likely to be discovered by predators, often the female dies soon after these activities are completed. However, direct care, protection of eggs and larvae are by no means unknown in the insect world. It reaches its height in the social bees, wasps, ants and termites where the nest community is totally geared to ensure the survival of the greatest possible number



Potter wasp nest



Potter wasp with prey

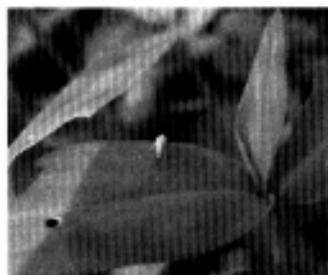
of new adults. For this a separate worker caste of non-breeding females have evolved, especially programmed to care for the immature stages of insects right up to their adulthood. Because of their elaborate organisation and display of ways of life, this appears analogous to our own, but such comparisons are out of place as the selfless care bestowed on the young by worker bees, wasps and ants is instinctive and robot-like. If there is any altruism apparent, it is probably the result of an inbuilt genetic programme.

Yet another instance of parental care is the example of single parents selflessly devoted to their progeny. The female earwig does not leave her batch of 40-60 eggs during the 2-3 weeks it takes for them to hatch; she licks and regularly turns the eggs to prevent possible fungal infection and defends them against intruders. She also feeds the tiny nymphs on her own saliva and regurgitated food. There are other examples of bugs, beetles and crickets which feed their larvae mouth to mouth.

As descendants from the relatives of millipedes, insects were originally land dwellers. But they developed wings at an early stage and so became pioneers in conquering air, which they alone ruled for more than 150 million years, into the jurassic period. Some insects left land and adapted to water. Some remained there for larval stages, others spent their entire life in water. Oceans are the habitats where insects are yet to adapt to.



Stick insect



Hopper

Size in the success of insects:

The maximum size of the insect body is limited by the non-living exoskeleton that cannot grow, and by the limited circulatory system that does not permit a large size. At one extreme we have the body mass of a few tropical beetles—the Hercules and Goliath beetles exceeding by far those of smallest birds—and

at the other end we have certain tiny parasitic wasps and the fireflies with body mass smaller than that of some paramecia—a medium sized protozoan.

At Rishi Valley the largest insect in terms of length is the stick insect; in terms of size and the wingspan, the Atlas Moth; some of the smallest seen (observable by the naked eye) are the 'eye-flies', the drosophilla and a species of paper wasp.

The small size of insects gives them many advantages in the struggle for existence. The quantity of food needed to nourish them individually is in itself very small and, therefore, many are able to live on such insignificant amounts of food materials that would be of no use to larger animals. Their small size also enables them to occupy niches in their surroundings that affords security from a whole range of enemies and, often, provides them with food at the same time.

Most insects seem to avoid being too small, and they also appear to avoid the other pitfall of being too big. This is because the smaller an animal becomes, the greater in proportion its surface area which causes the smallest of insects to become helpless if they become wet; the weight of the encompassing water speedily exhausts its effort to free itself. With larger insects with its relatively smaller surface area this complication has less consequence. It is not just chance that so few have bodies more than $\frac{1}{2}$ " - $\frac{3}{4}$ " in thickness. This is to enable, the internal air-tubes that end in extremely fine tubules to convey oxygen to the tissues by diffusion. Should an insect become too large, diffusion becomes ineffective; diffusion rapidly slows down when the tubules lengthen and the distance the air has to travel from the outside exceeds a certain limit.

It is very interesting to note that the largest insects are creatures with very long bodies or a relatively big wingspan. Stick insects are creatures with very long bodies or a relatively big wingspan. In the tropics stick insects are nearly a foot in length and small-bodied moths measure 11" across the wings. Large dragonfly fossils from the carboniferous periods show that nature has stopped experimenting with such sizes in insects. It is very rarely that an insect has the massive proportions of the African Goliath beetle with a length of 4" and a breadth of 2".

Colour in insects:

The colours of insects are just as diverse as their shapes. Nature has endowed them with a full palette of pigments to produce various hues. Look among the

thorny scrubs, and vegetation and you will find a colourful array of beetles, bugs, butterflies and moths. Although red, yellow and earthen colours are predominant, green and blue are not far behind. The colourful butterflies need no introduction; but the myth that moths are dull and drab should once and for all be scorched. Keep a white light burning at night and watch the moths that assemble! Their colours—varying hues of pink, green, yellow blue—would give the butterfly a run for its money. The beetles and bugs again would amaze any observer with their colourful parade! The shiny jewel beetles have been a collector's item and the colour has nearly lead many to the verge of extinction. Read more on these in the chapters that follow.

Though disastrous to many plants, the green june beetle, and *Chrysocoris* bug are brilliantly green in colour and therefore a feast to the eye. The lygaeid bugs are orange and red. The small ladybird beetles are a delight to watch and have been immortalized in stories and books.

The pigment that produce these colours is mainly melanin which ranges from yellow-brown to black and white, yellow or red pterines. Red carotene is derived from food-plants, but the green pigments in the skin and blood of green caterpillars and grasshoppers are made by the animals themselves and not the same as the ones found in the leaves they eat. Many effects of colours and lustre are brought about not by the pigments but by the fine structure, and the magnitude of the wavelength of light that is reflected in the outer layers of the cuticle. That the colours are due to optical effects is evident if one were to sprinkle a little benzene on the cuticle of a dead insect. The colour disappears. It reappears when the benzene evaporates away.

The more insects are studied, the more unique they are found to be and the less they have in common with many other animals. They are among the most permanent and persistent kinds of animals nature has evolved. The description, naming and classification of species is not the final goal of entomology, but rather a prerequisite for research; entomology should not be confined to laboratories. Nature lovers of all sorts have contributed to the present understanding of insect life and may their number increase.



3. Insects In Our Culture



Silver Greek coin of Ephesus
- 400BC showing a bee

As human populations flourished and became urbanized, one of the predominant development in the mind has been an intolerance for anything that was felt to be unpleasant. The response to such a context was to discover ways and means of eliminating the unpleasant. This seems to have been the predominant cultural evolution in the last few centuries and the organisms to suffer the most have been the insects. It's a paradox of our times that the researches and discoveries undertaken to produce materials and machinations to destroy insects are actually not doing them as much harm as they do to us, the propagators. No Rachel Carson or Nelson Mandela could do anything to change this psyche of humans.

However if one were to examine old texts and artifacts found preserved in museums, or listen to the tales and observe the practices of native people of the forests, indigenous tribes, and aborigines, then one would understand that there is a whole different way in which insects were looked at by ancient civilizations and cultures. It is fascinating to know that although insects are treated by layman as lowly organisms, they find a very important place in ancient civilizations, culture and literature. That their role in nature is an irreplaceable one has been acknowledged through ages, and we find them immortalized in art and architecture and in the rites and rituals of many civilizations.

We share with you some of the practices of various cultures which reveal the relationship they had with insects.

Dragonflies in mythology:

The ancient Mesopotamian civilization has citations of Odonata in the ancient poems of Gilgamesh. These citations clearly show that these people, regardless of their scientific awareness, were touched enough by the wonders of insects, including dragonflies, to refer to them within the literature of their time.

The dragonfly, now called 'tombo' in Japanese, used to be called 'akitsu'. Japan was once called Akitsushima meaning, 'The Island of the Dragonfly'.

Insects make sounds and these have caught the fancy of composers in olden days. Josef Strauss, son of Johann Strauss 1, was one such composer whose inspiration is revealed in the polka-mazurka dance composition 'The Dragonfly'.



Dragonfly

Here are a couple of lovely stories on dragonflies

- A Zuni Myth: *The Boy Who Made Dragonfly* (adapted from the story written by Tony Hillerman). Zunis are a Native American community, descendants of Pueblo People from New Mexico. This story describes the time when the tribe abandon their village in hard times to find food. A father and mother miss noticing that their children are fast asleep. These children, a boy and a girl, are left behind in the village. As time passes, the young boy to comfort his distressed younger sister constructs a toy insect out of corn and grasses. They amuse themselves with the toy. As time pass by, the toy comes to life. It begins to function as a messenger between the children and the gods. The insect later on is given the name of Dragonfly. This story used by Zunis to teach the young was first recorded in 1883.

- This is a story from Bellona Island which is a raised atoll in the Solomon Islands. Once upon a time a firefly wanted a drink. But it wouldn't go to the water during daytime. It called its friend the dragonfly to accompany it at night. As they went the dragonfly lit the way with his lantern. The firefly drank first,

while the dragon fly held the lantern and then it was time for dragonfly to take its fill, the firefly holding the lantern. As the dragonfly was drinking, the firefly ran away with the lantern, leaving it in the dark. So it is believed that with the lantern gone, the dragonfly now sleeps at night, and lives in and near the water. The firefly meanwhile is believed to roam at night, its way lit by the stolen lantern. (Source: *Animal Stories from Bellona Island* [Mungiki] by Rolf Kuschel, 1975; published by National Museum of Denmark.)



Scarab beetle

Beetle Elytra (forewings) in Art history

The colourful and vibrantly-structured beetles have fascinated humans from time immemorial. One of an earliest documented examples of the use of beetle wings can be seen in the Tamamushi shrine dating from 650 A.D in the Treasure Museum of the Horyu-ji in Japan. The wings of a beetle called 'tamamushi' were placed under bronze filigree ornaments on the

shrine. This masterpiece is dedicated to the Buddhist deity Shaka. Exquisite carving of insects are to be seen on Japanese swords.

In India some of the oldest documented uses of beetle wings are found in early Basohli School miniature Paintings from the Pahari Hills, an area which now lies within parts of the northern states of Himachal Pradesh, Jammu, the Punjab hills and Uttar Pradesh. Heavily ornamented figures with beetle wing encrusted jewels can be seen in several series of Basholi paintings.

India has been a rich source of beetle-wing embellished textiles and ornaments for many centuries. Well known objects such as 'desert jewelry', dolls and playthings, decorative fans, Jain sacred book covers, and *torans* decorated with beetle wings have been made by Rajasthanis.

Some of the finest and most elegant examples of beetle wing work come from the Mughal era in various costumes and garments (small pieces of the beetle elytra were often incorporated with heavy precious metal work). Many of these pieces were owned by the Royalty and were highly priced. The Bharat Kala Bhavan at Benaras Hindu University and the National Museum, New Delhi

house in their collections splendid examples of Mughal style sashes and Turban cloth. These *patkas* were crafted in the late seventeenth century.

Because of their brilliant metallic colouration, beetle wings are treated as if they were jewels much like emeralds. The Mughal enameling tradition of red or green on white, so well developed in Jaipur suggests a connection between the use of beetle wing textiles with heavy metallic work and green enameled jewelry. Several later textiles using beetle elytra embellishment can be found in the Maharaja Sawai Man Singh II Museum of the City Palace, Jaipur. These are dated in the 18th - 19th century. Maharaja Pratap Singh is reported to have worn on his wedding day in 1790, a garment utilizing beetle wings.

The people of Nagaland are of many varied groups where one group's language is incomprehensible to another group; also each group has different customs, beliefs and way of dressing. But with various Naga groups, ornaments and dress have been used for centuries as a language to communicate bravery and prowess, wealth, rank and prestige in completing various social obligations. Various Naga groups have used beetle elytra incorporated with other decorations to provide some of these social cues about the person's status in society.

In primitive and traditional cultures beetles are symbolized with Shamanic culture because beetles were observed to fly in the sky and dive into the ground in the same manner as shamans (medicine men) are able to 'fly' in the sky (in dreams or trances) and descend to subterranean hills where they act as mediators between *infernal powers and ordinary people*. Among Shamanic societies, there are series of myths relating the creation of the world to beetles.

In a more remarkable myth, an aquatic animal plunges down to the bottom of the original liquid chaos, manages to grab and bring back to the surface some amount of matter to form the terrestrial world; thus the primeval diver and maker of the world is a beetle. This myth is especially prevalent among the pre-Aryan people from India and S.E. Asia. The myth probably combines two different sorts of beetles: *Dysticid*, which has the ability to plunge and dive, and a scarab grabbing and pushing his dung ball. A number of hard-stone pendants dating back from prehistoric Egypt are often in the shape of Buprestid beetles. A small alabaster case in the shape of a scarab was designed to be attached to a necklace and might have been made to contain a true beetle.

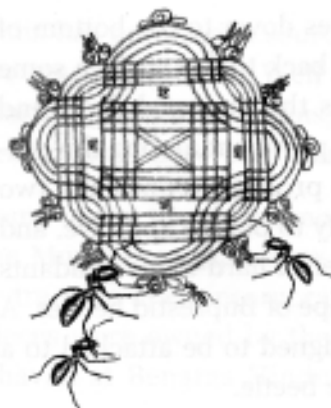
In Egypt, the primary symbolism associated with the scarab was solar; this symbolism came from the association of the dung ball to the sun; the scarab rolling its dung ball represented the sun's movement in the sky. They selected the scarab as a symbol of their sun God, Kherpa. Egyptian priests thought that what happened to the sun in the ground at the end of the day was not essentially different from scarab metamorphosis in which the old scarabs buried their balls of dung/eggs into the ground. Egyptian scholars or priests further developed their beliefs: the last stage of metamorphosis, the pupa, inspired the invention of the complicated process of mummification. The scarab became the most powerful symbol of the victory life wins over death. Painted on the wall of Tutankhamen's tomb, behind the Pharaoh's head is the ark of the sun sailing on nocturnal waters; the sun is represented as a beetle. This held out the promise of his rebirth the next morning, as well as the young Pharaoh's resurrection. A large 'heart scarab' was suspended from the mummy's neck with a gold chain, as a token of resurrection. The scarab has remained a favourite amulet throughout history, and hundreds of thousands of these tiny figures have been found in the Egyptian soil.

In Greece the insect was etched on coins, especially those of Ephesus.

Ants in our culture:

Ants go where humans go or perhaps the vice-versa should be true. There is a belief that the *kolams*, a kind of design which the women in Southern parts of India draw on the entrance to their homes using rice flour, served not merely

to beautify/sanctify their homes but also serve as food for ants. Unfortunately today the *kolams* are no longer made from rice flour!



In Japanese language the word 'ant' is intricately written by linking two characters: one meaning 'insect', the other 'loyalty'. Perhaps it's an acknowledgement of their altruistic and cooperative behaviour towards one another, nestmates readily going to war to protect their colony.

Ants feeding from 'kolam'

As ants and termites are seen in the soil, the Ancient believed them to be guardians of what was in the ground, as creatures who knew what lay below; they therefore revered them. The Greeks went to the extent of believing that the ants were responsible for the wealth of India, giving them gold from the soil.

But of more interest is the association one sees in these modern times, between the women of the Amazon Kayapo tribe and the red ants. For both, the red ants and the kayapo tribe, an important source of food is the manioc plant. The women of this tribe cultivate the plant and the ants visit their garden to sip nectar from it. While coming to the garden, the ants snip through several vines that would otherwise hinder the growth of the manioc and other plants. The women therefore revere these ants and there exists a symbiotic relationship between humans, plants and ants.

It's a pity that we do not learn from the solidarity and unified purpose of an ant colony which is a civilization in itself. Their cooperative and collaborative life style is lost on humans for whom there is only competition and individual concern; the team spirit of the ants is completely lacking in most humans.

Other insects:

An American Indian myth has it that butterflies were created because the Great Spirit wanted to love nature and seek out its beauty. They don't sting or bite and their beauty has elevated them above other insects, making them one of the few groups of insects to be immortalized in poetry and cared for with love. But their close cousins, the moths, who can parallel them in beauty and colour have found their place in our cultures only in a negative way. The beautiful iridescent blue Morphos were known in Central America as Royal blues. The Hopi and the Arapaho use the triangle to represent a butterfly.

Bees find mention in many sacred works such as the Rig Veda and the Quran. Honey was always described as sacred in all mythological stories.

The ancient Chinese regarded cicadas as symbols of rebirth or immortality.



Crimson rose



Grasshopper motif on pottery from New Mexico

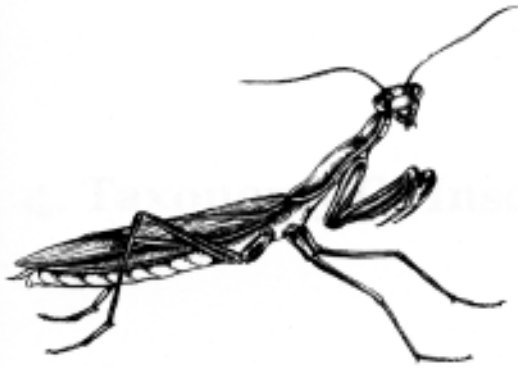
For the Bushmen of Africa, the Preying mantis was God. They prayed to the mantis. From what has been recorded by Sir Laurens van der Post, the Bushmen chose the mantis as their God for in it they saw an amalgamation of the characteristics of the human and the Divine.

The Austrian scientist Rudolf Steiner maintained that insects are a vital link between the physical world and the wave length of supportive energies especially the fire spirits.

It's a never ending story ... about how civilizations, tribes and people then and now have perceived and still perceive insects which we are now slowly and grudgingly beginning to accept as co-rulers of our world!



PART TWO



'What's the use of their having names,' the Gnat said, 'if they won't answer them?'.

'No use to them,' said Alice, 'but it's useful to the people that name them, I suppose'.

— Lewis Carroll

Alice Through the Looking Glass

4. Taxonomy Of Insects

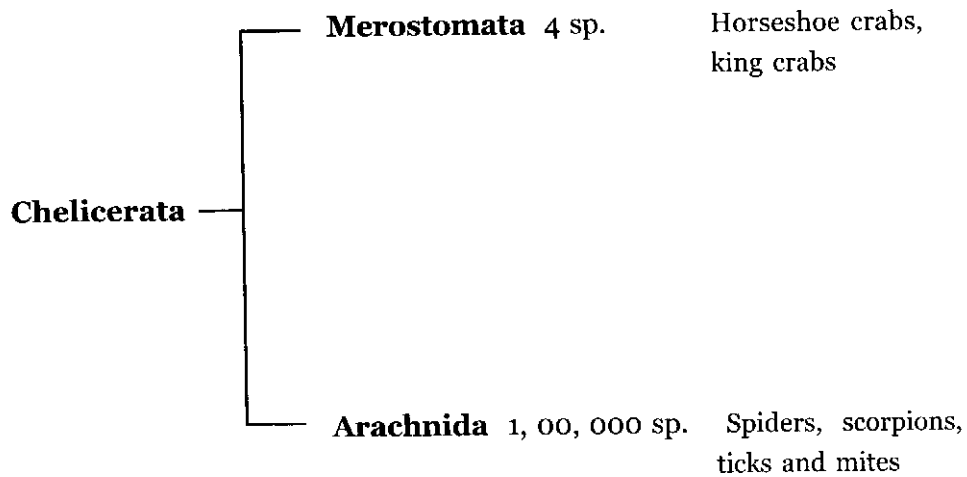
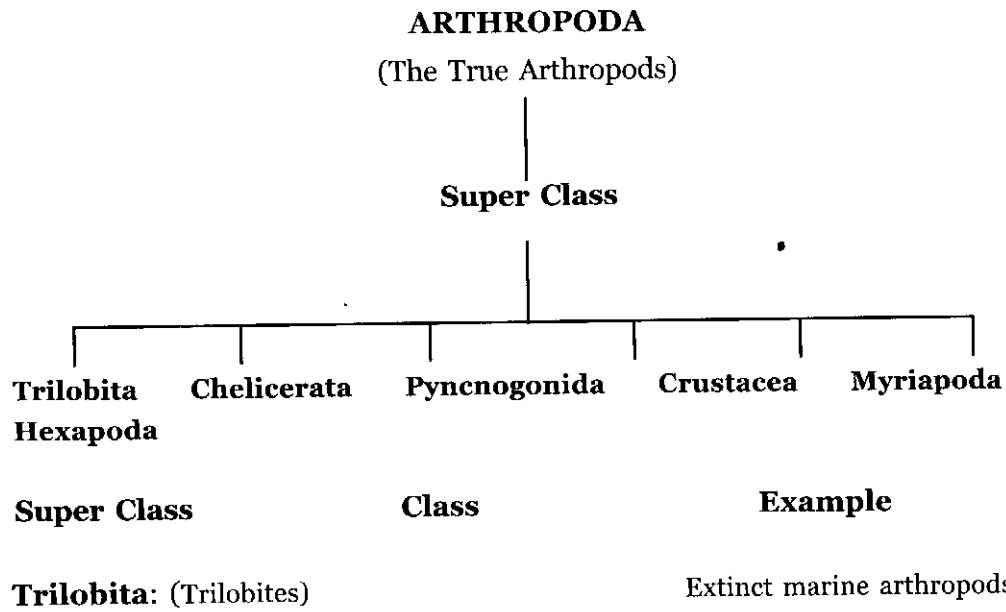
Taxonomy is the field of biology that deals with the classification and nomenclature (naming) of living organisms. Systematics, another modern term used in this connection, may be defined as the study of the diversity of organisms and the way they relate to each other, as well their connection with evolutionary lineage. Modern Systematics is therefore also called phylogenetics/cladistics and is governed by a set of well defined rules. However our objective here is to take those first tentative steps towards identifying the insects that we are observing.

But a word of caution. Taxonomy is full of contentious criteria, where different schools of thought decide the taxons differently — especially the general hierarchy of groups and the species. Arthropod classification, too, is in this nebulous field. Our research has taken us to different schools which propound different ways of classifying these organisms.

We have chosen the one given below for its simplicity and ease of usage for a layman wanting to study insects. It may or may not meet with the rigors of scientific standards, but it should certainly be of help to the amateur entomologist embarking on an observation in order to identify and study insects. This classification begins at the level of the Phylum Arthropoda— the reason being that there are so many organisms that are often mistaken for insects that, should doubts arise, this classification could then help in clearing them.

Given below is an outline classification of arthropods:

(No. of species is world-wide and not a measure of the locatity this book covers.)



Super Class	Class	Example
Crustacea	Remipedia 2 sp. Marine and primitive	Fairy shrimps
	Branchiopoda 900 sp.* Filter-feeding and marine	Crabs, shrimps, krills, lobsters and hermitcrab
	Malacostraca 22, 000 sp. Marine and some freshwater	
	Cephalocardia 9 sp. Small and marine	Bottom-feeding planktons
	Ostracoda 13,000 sp. shrimps, Bivalvate, marine/freshwater	Mussel and seed shrimps
	Maxillopoda 10,000 sp. marine and some freshwater	
Myriapoda	Pauropoda 500 sp. soil-dwelling, blind < 2 mm	Scavenging pauropods
	Diplopoda 10,000 sp. filter-feeding and marine	Millipedes
	Chilopoda 8,000 sp. Marine and some freshwater	Centipedes
	Symphyla 200 sp. soil-dwelling, blind, 1-8 mm	Herbivorous symphylans
Hexapoda	Para insecta	Collembola Springtails
		Protura Proturans
		Diplura Diplurans
	Insecta	Insects

Considering that there are over a million species of insects (56.3% of all described species are insects), any attempt to study them would necessarily require a basic understanding of their specialized features and, hence, some knowledge of classification.

Insect classification has undergone several changes over recent times as more and more species have begun to be studied in detail and described. Advances in molecular biology have provided taxonomists new insights into insect morphology, anatomy and physiology which has led to greater refinement in classification.

Units of hierarchy in classification

Kingdom:

Phylum:

Super Class:

Class:

Sub Class:

Super Order:

Order:

Sub Order:

Family:

Genus:

Species:

We provide below one of the current classifications of insects at the level of their orders. It is quite possible that by the time this book goes to print, the current classification would have undergone further modifications. The basic pattern followed here is drawn from *Insect Natural History* by A.D. Imms. However we have incorporated some changes that have been subsequently brought into insect classification.

The class Insecta is divided into two Sub Class: Apterygota and Pterygota, based on the primary absence or presence of wings. The pterygotes or the winged insects are further subdivided into Exopterygota and Endopterygota. In exopterygotes the wings develop externally and the metamorphosis is incomplete (as in cockroaches and grasshoppers). In endopterygotes the wings develop inside the body and the metamorphosis is complete (as in butterflies). The insect orders with examples are listed below, alphabetically, for easy reference.

Lepidoptera: Butterflies



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Pansies (*Junonia* sp.) 1. Lemon pansy (*J. lemonias*) 2. Blue pansy (*J. orithya*) 3. Yellow pansy (*J. hierta*) 4. Grey pansy (*J. atlites*) 5. Chocolate pansy (*J. iphita*) 6. Peacock pansy (*J. almanac*) 7. Evening brown (*Melanitis* sp.) UN 8. Tawny coster (*Telchinia violae*)

Lepidoptera: Butterflies



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1. Blue mormon (*Papilio polymnestor*) 2. Common banded peacock (*P. erino*) 3. Common lime (*P. demoleus*) 4. Common mormon (*P. polytes*) ♂ 5. Common pierrot (*Castalius rosamon*) 6. Angled pierrot (*Caleta*) 7. Plain tiger (*Danaïs chrysippus*) 8. Daniad eggfly (*Hypolimnys misippus*) ♀

Lepidoptera: Butterflies



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1. Indian cupid (*Everes* sp) 2. Southern grass jewel (*Chilades trochylus*) 3. Tiny grass blue (*Zizula gaika*)
4. Common Sailer (*Neptis hyla*) 5. Grass yellow (*Eurema* sp) 6. Nigger (*Orsotrioena medus*) 7. Gladeye bushbrown (*Mycalesis perseus*) 8. Common fourring (*Ypthima hubneri*) 9. Common fiveering (*Ypthima baldus*) 10. Golden-angle skipper (*Caprona ransonnetti*) 11. White orange tip

Lepidoptera: Moth



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1. Tasar silk moth (*Antheraea* sp.) ♀ 2. Tasar silk moth (*Antheraea* sp.) ♂ 3. Atlas moth (*Attacus taprobanis*)
4. Lunar moth 5. Hummingbird hawk moth 6. Hawk moth (*Marumba dyras*)

Lepidoptera: Moths



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1. Monkey moth (*Eupterote undata*) 2. Owl moth (*Erebus* sp.) 3. *Hyperlopha* sp. 4. *Amraica* sp.
5. *Agathia* sp. 6. Emerald moth (*Pelagodes* sp.) 7. *Heterostegane* sp. 8. *Problepsis vulgaris*

Lepidoptera: Moths



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1. *Cirrhochrista brizalis* 2. *Glyphodes stolalis* 3. *Entomogramma* sp. 4. *Mocis undata* 5. *Clostera* sp.
6. Plume moth 7. *Zeuzera* sp. 8. *Neoserura litorata* 9. *Xyleutes persona* 10. *Lymantriidae* moth

Lepidoptera: Hawk Moths (Family Sphingidae)



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1. Death's head hawk moth (*Acherontia styx*) 2. Convolvulus hawk moth (*Agrius convolvuli*) 3. *Hippotion* sp. 4. Oleander hawk moth (*Daphnis nerii*) 5,6. Yam hawk moth (*Theretra nessus*) 7,8. *Leucophlebia lineata*

Lepidoptera: Moths



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1-9 Family Aretiidae 1. *Creatonotos gangis* 2. *Aloa lactinea* 3. *Amata passalis* 4. *Argina astrea* 5. Unidentified tiger moth 6,7. Fruit piercing moth (6. *Eudocima homaena*; 7. *Eudocima materna*) 8. *Asota* sp. 9. *Argina argus* 10. *Syntomid* moth

Coleoptera: Beetles



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1. *Sternocera* sp. 2. Jewel beetle (*Chrysochroa* sp.) 3. *Buprestidae* indet 4. *Mylabris pustula* 5-7. Blister beetles 8. *Lema* sp. 9. *Chlaenius quadricolor*

Coleoptera: Beetles



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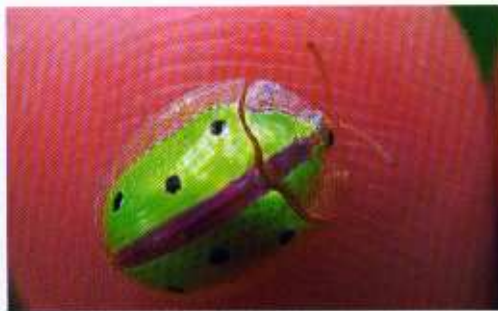
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1. *Prionoma attractum* 2. Longhorned beetle 3. *Apomecyna* sp. 4. *Aristobia octofasciculata*
5. *Tricstenotomia childreni* 6. *Platynotus excavatu*. 7. *Macrocheilus niger* 8. *Anthia sex-guttata*
9. Net-winged beetle 10. Firefly

Coleoptera: Beetles



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1. Tortoise shell beetle (*Apsidomorpha miliaris*) 2. Tortoise shell beetle 3. *Odontopus nigricornis*
4. Chrysomelid beetle 5. *Zygogama conjugata* 6. *Henosepilachna vigintiocto punctata* 7. *Nisotra semicoerulea* 8. Water beetle (*Dytiscus* sp.)

Coleoptera: Beetles



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1-8 Family Scarabidae 1.Dung roller. 2. Rhinoceros beetle (*Heliocopris tyranna*) 3. *Onitis philemon* 4. *Holotrichia* sp. 5. *Protetia alboguttata* 6- 7 *Heterorhina elegans* 8. *Holotrichia* sp. 9. Chrysomelid beetle(*Nodostoma* sp.)

Coleoptera: Weevils



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1,2. Mating weevils (*Mylocherus discolor*) Curculionidae

Hymenoptera: Wasps



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1. *Eumenes conica* 2. *Chelybion* sp. 3. *Rhynchium* sp. 4. *Sceliphron madraspatanum* 5. Digger wasp 6. Braconid wasp 7. *Ichneumon* sp. ♂ 8. *Ichneumon* sp. ♀

Hymenoptera: Wasps



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1. *Evania* sp. 2. *Sphex* sp. 3. *Ropalidia* sp. guarding an active nest 4. *Ropalidia marginata*. 5. *Vespa tropica* 6. Unfinished nest of *Vespa tropica* 7. Nest of *Polistes* sp. 8. Nest of *Ropalidia montana*

Hymenoptera: Ants



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1,2. Nest of *Pheidole* sp. 3. *Dorylus* sp. 4-6. Different species of *Camponotus* 7. Queen with wings (*Oecophylla smaragdina*) 8. Nest of *Oecophylla smaragdina*

Hymenoptera: Ants and Bees



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1. *Solenopsis* colony 2. *Tetraponera rufonigra* 3. *Crematogaster* sp. 4. *Xylocopa verticalis*
 5. *Megachile hera* 6. *Apis dorsata* 7. *Apis florea*

Heteroptera: Bugs



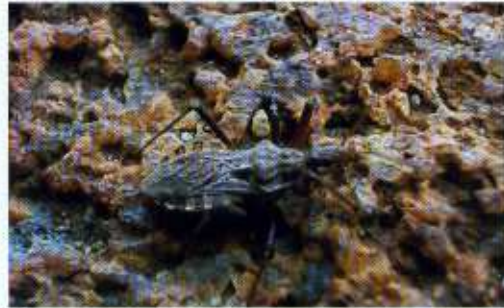
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1. *Cantao ocellata* 2. Bark bug (*Halys* sp.) 3. *Leptocoris oratorius* 4,5. Assassin bugs of Reduviidae
6. *Haematorhophus marginatus* 7. Leaf-footed bug 8. Tea mosquito bug (*Helopeltis antonii*)

Heteroptera: Bugs



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1. *Graptostethus servus* 2. *Lygaeus militarius* 3. *Leptocoris auger* 4. *Chrysocoris grandis* 5. Water strider 6. *Lethocerus indicus*

Heteroptera: Pentatomid Bugs



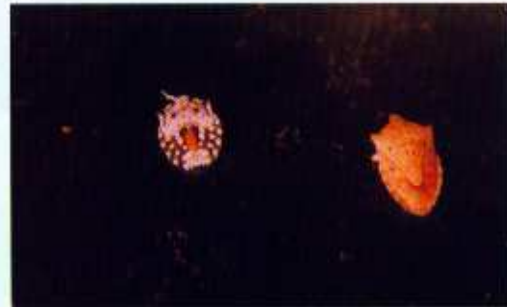
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1,2. Pentatomid nymph on the 1st & 2nd day of hatching 3. Shieldbug nymph 4. Nymph & immature pentatomid
5. *Erthesina* sp. 6. *Coridius ianus* 7. *Menida histrio* 8. Pentatomid bug 9. *Cyclopelta siccifolia*

Homoptera: Hoppers



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1. Fulgoridae nymph 2. *Eurybrachys* sp. 3. Fulgoridae (*Kalidasa* sp.) 4. Female scale insect (*Ceroplastes ceriferus*) 5. Eggcase of *Icerya purchasi* 6. Cowbug 7. *Dichoptera hyalinata* 8. Froghopper (*Clovia* sp.) 9. Spittle bug, nymph of froghopper

Mantodae: Mantids



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1. Preying mantis (*Hierodula* sp.) - adult 2. Nymph of *Hierodula* sp. 3. Bark mantis (*Humbertiella* sp.) 4,5. Nymphs of *Gongylus gongylodes* 6. *Gongylus gongylodes* ♀ 7. *Gongylus gongylodes* ♂

Mantodae: *Schizocephala bicornis*



Phasmatodea: Stick insects



Blattodea: Wingless cockroaches



Dermaptera: Earwigs



Ephemeroptera: Mayflies



Neuroptera: Ant-lions and Owlflies



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1, 3, 6 Ant-lions from family Myrmeleontidae 2, 4. Owlflies from family Ascalaphidae

Diptera: True flies



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1. Long-legged fly (*Dolichopodidae*) 2. Flesh fly from family *Sarcophagidae* 3. Blow flies from family *Calliphoridae* 4. Biting deer fly (*Chrysops* sp.) 5. Robber fly 6. Bee fly (*Bombylius* sp.) 7. Fly from family *Tephritidae* 8. Hover fly 9. Crane fly

Diptera: True flies



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1. Long-legged fly (*Dolichopodidae*) 2. Flesh fly from family *Sarcophagidae* 3. Blow flies from family *Calliphoridae* 4. Biting deer fly (*Chrysops* sp.) 5. Robber fly 6. Bee fly (*Bombylius* sp.) 7. Fly from family *Tephritidae* 8. Hover fly 9. Crane fly

Orthoptera: Grasshoppers



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1. *Acrida* sp. 2. *Atractomorpha* sp. 3. *Heiroglyphus* sp. 4. Coffee locust(*Aularches* sp) 5. *Neorthacris* sp. 6. Hooded grasshopper (*Teratodes monticollis*) 7. Painted grasshopper (*Poecilocera pictus*) - nymph 8. Painted grasshopper (*Poecilocera pictus*) – adult

Orthoptera: Bush Crickets (Katydids)



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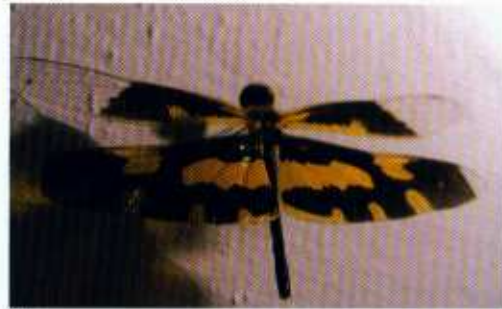
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1. Katydid from family *Phaneropterinae* 2. Bush katydid 3. Snout-nosed katydid 4. False-leaf katydid
5. *Mecopoda* sp. 6. Long-legged katydid 7. Katydid from family *Conocephalinae* 8. Cone-headed katydid

Odonata: Dragonflies and Damselflies



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1. Ditch jewel (*Brachythermis contaminata*) 2. Common Picture Wing (*Rhyothemis variegata*) 3. Ground skimmer (*Diplocodes trivialis*) ♂ 4. *Diplocodes trivialis* ♀ 5. Wandering glider (*Pantala flavescens*) 6. Forest skimmer (*Neothermis* sp.) 7. Damselfly (*Ceriagrion coramandelianum*) ♀ 8. Damselfly (*Pseudagrion* sp.) ♂

Larval forms of insects



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Larvae of 1. *Eumeta* sp. 2. Caddisfly 3. Coccinellid 4. Nymph of coreid bug 5. Ant-lion 6. Larva of firefly 7. Larva of Ladybird beetle 8. Hoverfly larva feeding on aphids 9. Pupating lemon pansy 10. Caterpillar of common crow 11. Caterpillar of tawny coster

Caterpillars and Pupa of Moths



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1. Moth (*Xanthodes* sp.) 2. Moth (*Orgyia* sp.) 3. Butterfly (*Papilio polytes*) 4. Caterpillar of Oleander hawk moth beginning to pupate 5. Unidentified cocoon 6. Pupating *Brachmia effera*. 7. Cocoon of *Tasar* silk moth. 8. Cocoon of preying mantis

Camouflage and Mimicry



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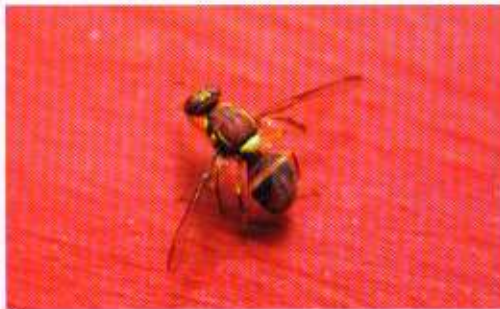
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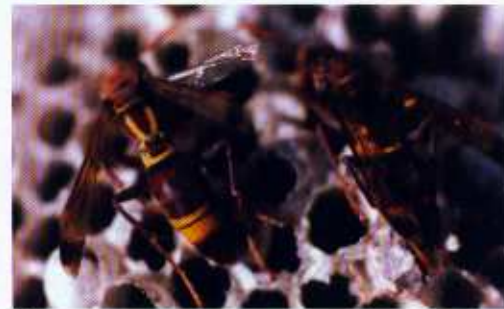
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Camouflage: 1. Preying mantis (*Schizocephala bicornis*) 2. Moth (*Phalera grotei*) 3. *Gongylus* on *Ficus* sp.
Mimicry: 4. Mantid (*Euantissa pulchra*) an ant mimic 5. Spider mimicking an ant 6. A fly (*Dacus zonus*)
mimicking a paper wasp of *Ropalidia* sp. shown in 7

Mimicry - Butterflies



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1. Great eggfly (*Hypolimnys bolina*) ♀ UN 2. Great eggfly ♂ UN 3. Great eggfly ♀ UP 4. Great eggfly ♂ UP 5. Common crow UP, 6. Common crow UN, 7. Common mormon mating 8. Crimson rose

Alphabetical list of insect orders in current usage:

1.	Blattodea	Cockroaches
2.	Coleoptera	Beetles
3.	Collembola	Springtails
4.	Dermaptera	Earwigs
5.	Diplura	Diplurans
6.	Diptera	Flies
7.	Embioptera	Web spinners
8.	Ephemeroptera	Mayflies
9.	Grylloblattodea	Rock crawlers
10.	Hemiptera	Bugs, cicada, hoppers and scale insects
11.	Hymenoptera	Ants, bees, wasps and sawflies
12.	Isoptera	Termites
13.	Lepidoptera	Butterflies and moths
14.	Mantodea	Preying mantis
15.	Mantophasmatodea	
16.	Mallophaga	Biting lice and bird lice
17.	Mecoptera	Scorpion flies
18.	Neuroptera	Lacewings, alderflies, snakeflies and antlions
19.	Odonata	Dragonflies
20.	Orthoptera	Grasshoppers, locusts and crickets
21.	Phasmatodea	Stick and leaf insects
22.	Plecoptera	Stoneflies
23.	Protura	Proturans
24.	Psocoptera	Booklice
25.	Siphonaptera	Fleas
26.	Siphunculata	Sucking lice
27.	Strepsiptera	Stylopids
28.	Thysanoptera	Thrips
29.	Thysanura	Bristletails and silverfish
30.	Trichoptera	Caddis flies
31.	Zoraptera	Zorapterans

Thus the orders numbered 3, 5, 23 and 29 are apterygotes; 1, 4, 7, 8, 9, 10, 14, 16, 19, 20, 21, 22, 24, 26, 27, 28, 29, 31 are exopterygotes and 2, 6, 11, 13, 17, 18, 25, 27, 30 are endopterygotes.

A simplified version of classification goes thus: Kingdom, Phylum, Class, Order, Family, Genus and Species.

If you have a problem remembering this hierarchy, then remember this:

Kings Play Chess On Fine Grain Sand

Thus if you have to classify the **house fly**, this is how it would be

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Diptera

Family: Muscidae

Genus: *Musca*

Species: *domestica*

Identifying insects:

Insects will never stop to surprise you. On the field, while you think you are watching a fly, it might, when you are attempting to identify it, turn out to be a bee. So beware, for there are masqueraders and masqueraders in the insect world: ants looking like wasps, wasps looking like bees, flies looking like bees and so on and so forth; mimicry, after all, is a remarkable adaptive trait and insects have taken advantage of it in their bid to conquer their odds for survival.

The table below gives a very generalized account of some common features of each order. It is by no means extensive; for each of the orders and each of the characteristics mentioned, there are several more details not mentioned here. You will find some more characteristics described in the section that follows. This table is meant to merely help you decide the order to which the insect you wish to study may belong.

Features of the Common Insect Orders : An Outline

The table below gives a very generalized account of some common features of each order. It is by no means extensive; for each of the orders and each of the characteristics mentioned, there are several more details not mentioned here. You will find some more characteristics described in the section that follows. This table is meant to merely help you decide the order to which the insect you wish to study may belong.

Insect Order	Example	Antenna*	Mouth Parts	Wings	Tarsi in leg#	Meta-morphosis†	Habit & Habitat	Remarks
Blattodea	Cockroach	Many segments, hair-like, long	Chewing and biting	2 pairs FW leathery tegmina	5	Incomplete	Terrestrial	Some forms are wingless too
Coleoptera	Beetles	Varied: threadlike, clubbed., pectinate, 8-10	Chewing	2 pairs, outer pair thick hard elytra	3-5	Complete	Terrestrial, aquatic	Most speciose order in the animal kingdom
Collembola	Springtails	Present	Chewing	Absent	1	Simple	Leaf litter, bark	Very small in size, jump using tail appendages
Dermaptera	Earwigs	Threadlike, sometimes folded, half the size of the body	Chewing and biting	FW short, HW folded beneath it; abdomen visible	3	Incomplete	Nocturnal, scavenger. Some males can bite; Crevices, bark, etc.	Winged & wingless forms exist; cerci as forceps
Diplura	Diplurans	Short, 3-5, moniliform or bead-like	Biting	Wingless	1	Simple	Grasslands and wood-lands	

Insect Order	Example	Antenna*	Mouth Parts	Wings	Legs*	Meta-morphosis†	Habit & Habitat	Remarks
Diptera	Flies	Variable, typically short, 3	Piercing, sucking and sponging	1 pair. HW reduced to knob like halteres	5	Complete	Vegetation of all kind; all habitats	
Embioptera	Web spinners	16-32, short thread-like segments	Chewing and biting	Male - 4 Female wingless	3. Silk gland in foreleg	Incomplete	In debri	
Ephemeroptera	Mayflies	Small, bristle-like, hardly noticeable	Adults do not feed	4, triangular membranous, many veined	3-5	Incomplete	Close to aquatic areas	Larvae aquatic Long tail appendages
Grylloblattodea	Rock crawlers, icebugs	Filiform (Long & thin) 28-40	Biting and chewing	Adult Wing-less	Large coxa; 5	Simple	Nocturnal, under snow or gravel, rock crevices	2-3.5 cm long. Not found in India
Hemiptera	Bugs, cicada, plant hoppers	5 or less, varied in size	Piercing and sucking	4; tip of wings scutellum; membranous in some	1-3 in bugs, 2 or 3 in others	Incomplete	Everywhere; only one in marine habitat	Many wingless

Insect Order	Example	Antenna*	Mouth Parts	Wings	Legs*	Meta-morphosis+	Habit & Habitat	Remarks
Hymenoptera	Ants, bees, wasps, sawflies	Varied, Long, 10 +, thread-like in some; elbowed in all ants & some wasp	Chewing and biting/lapping	HW smaller than FW hooks on HW.	5	Complete	Variety of habitats; complex behavior	Wings absent in certain castes; ovipositor used for stinging
Isoptera	Termites, white ants	Short, or bead-like.	Chewing	4, equal sized,, long, membranous	4	Simple but have castes	Ground or on fallen wood	Colonial, workers & soldiers wingless;
Lepidoptera	Butterflies, moths and skippers	Long, slender & clubbed in b'flies; filiform, pectinate in moths	Sithoning type	4, scaly wings	5	Complete	On vegetation	Moths show a variety of antenna forms
Mantodea	Preying mantis	Short, thread-like	Chewing	4, FW; thick, HW membranous	5, Foreleg raptorial for grasping prey	Incomplete	Bushes; attracted to light	Slowmoving, large insects; predaceous & carnivore;

Insect Order	Example	Antenna*	Mouth Parts	Wings	Legs*	Meta-morphosis*	Habit & Habitat	Remarks
Mallophaga	Biting lice, bird lice	Short, 3-5; concealed in grooves of the head.	Chewing	wingless	1-2 tarsi with 1 or 2 claws	Simple	Parasitic on birds	Parasites on birds and mammals
Mecoptera	Scorpion flies	Threadlike, half the body length	Chewing; head prolonged into a snout	4, similar; some wingless	5	Complete	Vegetaion	Tip of male abdomen is swollen hence the name; harmless
Neuroptera	Lacewings, alderflies, snakeflies, antlions	Long, thread-like, pectinate, clubbed, many segments	Chewing. Some do not feed.	4, many veined; held roof-like over body	5	Complete	Aquatic, predaceous	Some look like dragonflies but are more fragile looking
Odonata	Dragonflies, damselflies	Very short, inconspicuous, bristlelike	Chewing and biting	4 many veined membranous, equal size	3	Incomplete	Aquatic, adult & larva carnivorous	Large conspicuous eyes, long body
Orthoptera	Grass-hoppers, locusts, katydids, crickets	Filiform, setaceous, long or short	Chewing and biting	4, front pairs leathery	3-4 jointed; H-limb modified for jumping	Incomplete	Vegetaion	Males often produce sound by rubbing forewings

Insect Order	Example	Antenna *	Mouth Parts	Wings	Legs*	Meta-morphosis*	Habit & Habitat	Remarks
Phasmatodea	Stick & leaf insects	8-100, long & slender in stick insects, short in leaf insects	Biting and chewing	Winged or wingless	Leg segments long and slender; 5 tarsi	Incomplete	Trees & bushes in forests	Masters of camouflage; eggs resemble seeds
Plecoptera	Stoneflies	Long thread-like	Chewing	HW has lobe, folded to fit under FW	3 tarsi small coxae	Incomplete	Close to aquatic areas	Poor fliers, nymph aquatic
Protura	Proturans	No antennae (head conical and no eyes)	Sucking	Wingless	1	Simple	In debris, around roots, humus, rotting bark	1 st pair of legs sensory.
Psocoptera	Booklice	Long and slender, threadlike 12-150	Chewing (gnawing)	Some wingless; in others wings held roof-like	2-3	Simple	Scavengers; household pests	No cerci; has a head with bulbous appearance
Siphonaptera	Fleas	Short, 3, fitting into the grooves of the head	Sucking	Wingless	Large coxae, 5	Complete	Parasites of birds, mammals	Larvae are scavengers. Capable of jumping

Insect Order	Example	Antenna ⁺	Mouth Parts	Wings	Legs [*]	Meta-morphosis ⁺	Habit & Habitat	Remarks
Siphunculata (Anoplura)	Sucking lice	Short, 3-5, tapering distally, thread-like	Sucking	Wingless	Tarsi 1 with 1 claw	Simple	Parasitic on mammals	Eggs, called nits, are glued to hair
Strepsiptera	Stylopids, twisted wings	4-7, some segments have lateral processes, appears branched.	Vestigial	FW club-like, HW large & fan like; no wings in females	2-5	Complete	Hyper meta-morphosis reported.	Parasites on bees, grasshoppers; bugs, wasps
Thysanoptera	Thrips	Short, 6-9 segments	Piercing, sucking	4, fringed with hairs; narrow, veins reduced	1-2 legs without between claws, with bladder-like tip	Inter-mediate leaves simple & complete	Flowers, axils of	Phytophagous, predatory;
Thysanura	Bristletails, silverfish	Long & many segments	Chewing	Wingless	1-5	Simple	Houses, inside books, under stones	2 cerci & medial caudal filament

Insect Order	Example	Antenna*	Mouth Parts	Wings	Legs [#]	Meta-morphosis ⁺	Habit & Habitat	Remarks
Trichoptera	Caddis flies	Long & thread-like body length	Chewing and biting, often non-functional	Hairy; held folded flat and tentlike over the body	5, long, slender legs	Complete	Larvae aquatic make cases and tubes to dwell	Adults moth-like; larvae resemble caterpillars
Zoraptera	Zorapterans	Beadlike, 9	Chewing	Winged and wingless; forms	2, spines on expanded femora	Simple	Saw dust, piles of wood bark, rotting logs	Wingless, blind forms dominant; look like termites

Note:

*Numbers mentioned under antenna refer to the numbers of segments found in the antennae.

#The numbers given under the column 'legs' refer to the number of segments in the tarsals of the leg.

+Metamorphosis : Hemimetabolous- Simple; Paurometabolous—incomplete; Homometabolous—Complete

Symbols used: FW - Forewing, HW Hindwing.

Mantophasmatodea: A new (31st) order of insects has been identified - the first since 1914. (*Science, 24 May 2002: Vol. 296, no. 5572, pp. 1456 - 1459* by Klaus-D. Klass, Oliver Zompro, Niels P. Kristensen, Joachim Adis DOI: 10.1126/science.1069397) Discovered in western Namibia on the Brandberg Mountain, these insects show a mixture of features noticeable in grylloblatids and phasmids. Considered a living fossil (a specimen was found trapped in amber that was 45 M years old) one of the entomologists was quoted by BBC as saying that this discovery was comparable to finding a living mastodon or sabre-tooth tiger.

The keys given above can take you up to placing the insects in their respective orders. But you must find the Genus and Species of an insect for the identification to be complete. Such a description will satisfy the norms of the classical binomial nomenclature put forward by Carl Linnaeus which is universally accepted by all. To do that you would need to look for more details. If you have successfully found the orders of the insects that fascinated you, we are sure you would be able to take the next few steps of completing the identification. This book will help in identifying a few select insects from each order.



5. A Description Of Select Insects

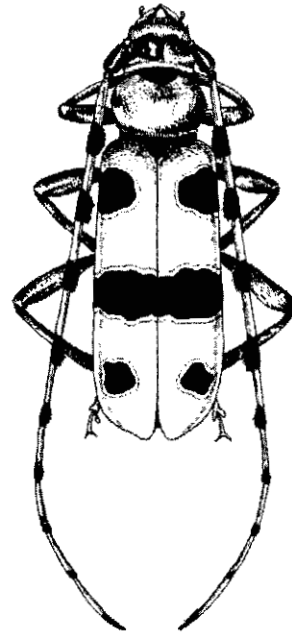
In this chapter we give you descriptions of some of the common insects we observed mostly at Rishi Valley. We must add that we have also seen many of these species in several parts of Tamilnadu, Karnataka and Andhra Pradesh. Some of them, with minor variations, have been observed in parts of Maharashtra as well.

In describing these insects we have used common names and wherever we were sure of our identification, we have given the species and genus names as well. Our use of common names would be frowned upon by the scientific community, but our goal was to reach out to youth and get them interested in insects. From our experience we have noticed that a reluctance sets in when binomial nomenclature was used to describe organisms. This is not an excuse, for we are also fairly certain (and again from our experience) that if we can garner the interest of people in insects, getting to know the insects at the species level would follow naturally.

The orders described below are randomly arranged, beginning with butterflies, so liked by all.

ORDER: LEPIDOPTERA

We have identified and studied 53 species of butterflies and 15 species of moths. RV should have at least 40-50 more species of moths. We have been able to identify and study only about 15 of them which can be easily seen.



Longhorn beetle

Lepidoptera means 'insects with scaly wings'. Two major representative groups of the Order Lepidoptera are butterflies and moths, and we give a brief idea of how to differentiate moths from butterflies. It is a wrong understanding that moths are invariably dull while butterflies are brightly coloured. Although moths are seen in larger numbers at night, they have been spotted during day time too. Similarly, there is a group of butterflies generally called 'Browns' that are seen, flying and feeding towards the evenings.

While butterflies have clubbed antennae, moths have feathery antennae, which is their most distinguishing feature. Moths have the habit of tucking their antennae beneath their heads and their bodies have a very distinct hairy nature. The bodies of moths appear stocky in many species, while most butterflies have slender bodies. Butterflies hold their wings vertically upwards while at rest (there are some exceptions), whereas moths usually keep their wings folded, roof-like over the abdomen which appears V-shaped; rigidity of the wings is ensured differently in butterflies and moths while flying. In moths the wings are locked together by stiff bristles.

The eggs of butterflies are dome-shaped, upright and sculpted; moths' eggs are rounded, flat or scale-like.

Caterpillars have 5 pairs of sucker legs; one or more pairs may be absent or reduced in moths. Moth-caterpillars have hairs arranged in tufts or are covered with thick hairs, whereas the caterpillars of butterflies do not have hairs thick enough to cover their body surface; they have spines and not tufts. The chrysalides of butterflies hang from a twig, or may be secured by a body-band, or be enclosed within a leaf. In moths they are usually contained in a cocoon, completely enmeshed by silky hair, or pupate underground. Many moths survive unfavourable conditions by extending the pupal state.

We give below a few families of butterflies and moths commonly seen in Rishi Valley and elsewhere in the Southern Peninsula of India.

FAMILY Danaidae

Large tough insects of slow flight; eggs are generally domed and ribbed, laid singly on the underside of a leaf. Asclepidaceae and Apocyanaceae are the preferred plant families. Natural enemies are birds, lizards and wasps which prey on their caterpillars.

1. Tigers

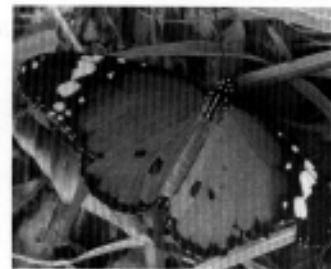


Blue tiger

Large black or dark brown; pale, transparent markings as streaks in both wings; flight is slightly slow and lazy unless disturbed or frightened; congregate in large numbers clinging to branches of plants such as *Crotalaria sp.* Common species are the glassy tiger (*Parantica aglea*) and the blue tiger (*Tirumala limniace*) generally seen in great numbers in summer months.

2. Tawny tigers

Wings are tawny in colour with a white-spotted black apex; males have a pouch on the hindwings; gregarious by habit; stronger fliers than glassy tigers. Seen practically throughout the year in the plains. Commonest in India; found almost throughout India on Milkweed plants, *Crotalaria sp.* and *Tridax sp.* Females of the daniad egg fly (*Hypolimnas misippus*) mimics the plain tiger. The common or the striped tiger is called the Monarch Butterfly in the West and its migration patterns have been recorded from Rayalaseema to Tamilnadu around October.



Plain tiger

3. Crows

Large, long-winged, glossy-brown or glossy-black butterflies; sometimes have a shade of blue in the forewings; white marginal and terminal spots and streaks seen; hindwings generally have a marginal and terminal series of spots. Their



Common crow - underside

flight is slightly weak and like the tigers, the crows rest in the heat of the day, often in large congregations, on plants, wet roads and damp patches. The great egg fly (*Hypolimnys bolina*) is a common mimic of the common Indian crow (*Euploea core*). Along with the other daniads, the common crow is also known to migrate. Look for them around plants such as *Nerium* sp.

FAMILY Satyridae

Commonly called the browns, these are mostly inconspicuous, dull brown or blackish butterflies of moderate size. There are eye-like spots (ocelli) on the upper and underside of the wings. Eggs are white, melon-shaped, grooved or partitioned into cells. Caterpillars are brown, green, pink or yellow. Food plants for larvae are grasses or sometimes palms.

These are creatures of forests and jungles and prefer to remain in the shade to venturing out into the open. Flight is slow, jerky or bouncing; prefer to settle down frequently; short lived. Their colouration varies with the season.

Browns



Evening brown

Bush browns: The tamil bush browns and dark band bush browns.

Evening brown: Dark brown, leaf-like butterfly that flies in the evenings. Forewings are angular.

i. Common evening brown has two large black spots with white on the forewings; three small black spots with white on the hindwings. During daytime it

shelters in the underside of bushes and if disturbed can be seen taking off to land again some distance away. Very fond of ripe fruit and toddy. ii. Great Evening Brown is another species seen in Rishi Valley.

The Rings: Found in grassy places; flutter about close to the ground; fly in a hopping, bouncing way. Can be identified by counting the 'eyes' on the underside of the wings.



Common threeering

FAMILY Nymphalidae

Nearly always brightly- or brilliantly-coloured butterflies. The wings are of varied shapes and the hindwings may be tailed, toothed, scalloped, sharply angled, indented and sometimes rounded. In size the nymphalids may vary from very large (135 mm expanse) to very small (25 mm expanse). Thus it is a very heterogenous group. Eggs are domed, white; most nymphalids fly fast, but the methods of flight are varied. This family displays several interesting examples of mimicry. Nymphalids can be seen on a wide variety of food plants from trees such as the peepul and banyan, mango and *Pongamia* to others such as passion flower, *Abutilon*, *Portulaca* and *Justicea* sp.



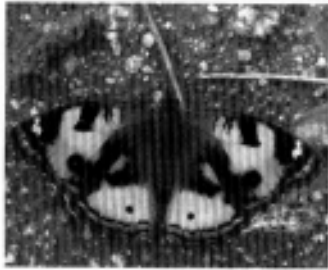
Euthalia aconthea

1. Baron (*Euthalia aconthea*): Favourite food plants are mango and cashewnut and can be seen in their vicinity. Light brown which glows with a purplish tinge when sunlight falls on the wings. Flight is strong and rapid; they have a habit of settling on the ground with wings outspread. The caterpillar rests on the midrib of the mango leaf with its spines laterally branched appearing like the veins of the leaf, a striking example of mimicry not only in terms of protective colouration but of structure and habit.

2. Egg Fly (*Hypolimnys* sp.): There are two types – the daniad and the great egg fly. The genus is remarkable because it exhibits variation between the sexes and even between individuals. They are great mimics of Daniads. The female of the Great Egg Fly mimics the Common Indian Crow and can be distinguished from it by the scalloped border in the wings. The male is brilliantly violet in colour and presents a striking appearance. It has the tendency to chase away any butterfly that comes close to its perch. Food plants are *Portulaca*, *Abutilon* and other Malvaceae sp.



Great egg fly male



Junonia hierta female

3. Pansies (*Junonia sp.*): Most abundant and prettiest of Indian Butterflies; moderate or fairly small in size characterised by the presence of ocelli or eyes on the discal area of both wings. Flight is strong, straight and rapid, close to the ground. Never fly far but soon settle on the ground or on flowers with wings held open or sometimes opening and closing them again. Food plants are generally Acanthaceae (e.g. *Justicia*, *Barleria*). Yellow Pansy, Blue Pansy, Lemon Pansy (commonest), Chocolate Pansy and Peacock Pansy can be spotted in RV. Grey Pansy is the only one from this group, that is not spotted at Rishi Valley. It prefers the wetter regions of the country.

4. Painted Lady (*Vanessa cardui*): Feeds on Compositae, Malvaceae or Leguminosae. Owes its occurrence to the fact that its caterpillars feed on such a variety of the most successful of flowering plants. Found both in the plains and on the hills — from deserts to high altitudes. Pinkish-red with black markings; a strong and swift flier but settles frequently on the ground or sometimes on leaves. When resting the wings are closed and held in such a manner that the insect is difficult to spot against the earth on the ground (camouflage).



Vanessa cardui



Atella phalantha

5. Leopard (*Phalanta phalantha*): Very commonly seen butterfly, tawny in colour with rows of black spots. It shuns shady places, flying most commonly during the dry weather. It is attracted to flowers of *Lantana*, *Duranta*, *Tridax*, etc, on which it settles with wings half open, or else quickly flitting from blossom to blossom. Like many other butterflies it is found drinking from damp patches and from wet roads in hot weather.

6. Castor (*Ariadne merione*): Dark, reddish brown in colour with slender black lines across the upper side of both wings. Weak fliers, they keep close to their food plants which are castor and all members of the Euphorbia family.



Ariadne merione

7. Joker (*Byblia ilithyia*): Bright, tawny with narrow black markings. Colouration varies seasonally. It is confined to dry open plains seen around hedges keeping to their immediate food plants, *Tragia cannabina* or member of Euphorbiaceae.

8. Sailor (*Neptis sp.*): Colour is black or dark brown with three horizontal bands. These bands are white or yellow. The common sailor has white bands, the horizontal bands being the characteristic feature of identification. They resemble the sergeants from whom they can be distinguished by looking at the colouration on the abdomen. Sergeants have a small blue patch on the abdomen. Sailors can be recognised by their flight which is graceful, sailing with the wings held quite horizontal. They do not fly close to the ground.



Neptis sp.

FAMILY Acraeidae

The majority of the 200 species in this sub-family are African. India has only two representatives. One of them is *Telchinia violae* or tawny coaster which is orangish-red above with narrow dark ends on the forewings. The borders of the hindwings are black, bearing white spots. There are a series of black spots seen on the two wings. Its larvae feeds on Cucurbitacea (cucumber) and on passion flower plant. They exude an oily, evil-smelling fluid which is obnoxious to birds and thus protects them from their predators. Eggs are yellow and domed.

FAMILY Erycinidae: Plum Judy

There are 21 Erycinids in India, and all are small butterflies. The structure of the forelegs is the main characteristic, these being brush-like in the male but completely developed in the female. These are generally confined to the wooded country, many of them preferring thick forest. Their flight is rapid but short. The Jadies always settle with wings half open. Eggs are small white and domed.

Shade-loving insects, more of brown in colour, the hindwings have a pointed beak-like appearance (can be seen resting on *Tridax*).

Family Lycaenide: Blues

A family very difficult to identify, very small in size with blue as the predominating colour. Females are less conspicuously coloured than the males. Many of them have tails. Some blues have a very unique protective mechanism in which they use the tail which is structured to resemble the anterior portion of the butterfly: when a bird attacks them, only a small portion of their tail is injured as the butterfly escapes to safety. Eggs are small, turban shaped or domed, white or pale green.

This group has a symbiotic association with ants and in some cases the ants are found to guard the caterpillars of the species. The larvae of silverlines are always attended by ants. Whereas those of peablues and pierrots are intermittently attended by ants. Their most preferred food plants are the leguminous variety. Two Indian species are known to be carnivorous. Caterpillars of the apefly (*Espalgis epius*) feed on scale insects and those of the moth butterfly (*Liphyrae brassolis*) on ant larvae.

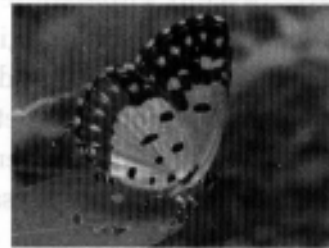
The different types of Lycaenides:

- 1) The Red Pierrots
- 2) The Pierrots {
 - Common Pierrot (*Castalius rosimon*)
 - Angle Pierrot (*Caleta caleta*)
- 3) The Zebrablues
- 4) The Hedgeblues
- 5) The Grassblues
- 6) Ceruleans
- 7) Limeblue
- 8) Cupids (Gramblue)
- 9) Peablues
- 10) Silverlines

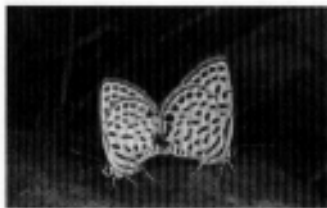
Description

1. Red pierrot (*Talica niseus*)

Seen throughout India, its larvae feed on leaves of *Bryophyllum* and *Kalanchoe* and therefore the butterflies are seen on flowers of these plants. Colouration is unique and cannot be mistaken — orange and black border on the wings.



Red pierrot



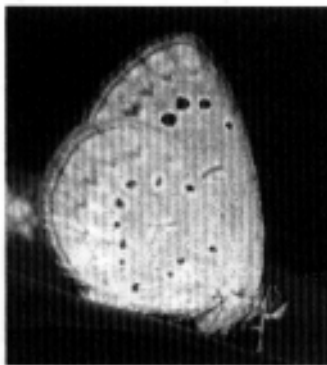
Forest or dark pierrot

2. The Pierrots

Small in size, white in colour with dark or brown spots or streaks of black markings which are unique to each species. Two species seen are the Common Pierrots and the Angle Pierrots. They feed on any species of *Ziziphus*.

3. Zebrablue (*Syntarucus plinius*)

Common, transparent, pale, violet-blue above and below with irregular, alternative, broad and narrow brown bands on a whitish background. Tailed hindwings; prefers drier parts. Flies rapidly and feeds on *Indigofera* sp., *Albizia lebek*, and *Sesbania grandiflora*.



Grassblue

4. Grassblue (*Zizeeria* sp.)

Very tiny in size (15 to 20 mm only), blue above with dark borders, or brown with or without basal blue scaling. They do not have any tail and the underside of the hindwings always wear a small spot. The Grass Jewel is the smallest of all Indian butterflies. All keep to open grassy places and fly weakly very close to the ground and hence the popular name. They are fond of sunshine and bask with their wings partly opened, but when they feed or rest, they keep them closed over their backs. Their food plants are low-growing leguminous plants or Acanthids.

5. Hedgeblue (*Lycaenopsis* sp.)

Irridescent violet-blue with black margins. In females the black margins are broad with white patches. Although abundant in the Himalayas and other hilly regions, a variety has been spotted at Rishi Valley although infrequently. Feeds on plants from the family Sapindaceae (sapota), Leguminosae and Combretaceae.



Hedgeblue

Family Lycaenidae: Blue**6. Cerulean (*Jamides* sp.)**

Common cerulean

Bluish white to azure blue above, more or less narrow black outer margin reduced considerably on the hind wing. On the underside there are three marginal white lines on both wings and these margins and the arrangement of these marking are a clue to their identification.

The Common Cerulean is a very common butterfly found almost in every habitat and elevation except in the arid northern parts of the country. It prefers to fly in the half shade or at the edges of woods or jungles. It likes to drink from the wet patches on damp ground, always with the wings closed. *Pongamia*, *Butea* and plants of Sapindaceae family.

7. Peablu (*Lampides boeticus*)

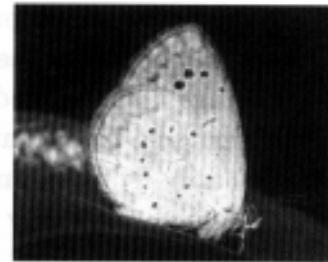
It is pale brown below with a whitish, narrow brown band and two black orange-crowned spots on the hindwings; dark brown above with a shade of blue near the basal part. Among the blues this is the most widely distributed species. Hindwings are tailed, the tail arising between the two black spots. It is a common migrant that feeds on legumes.



Peablu

8. Limeblue (*Chilades sp.*)

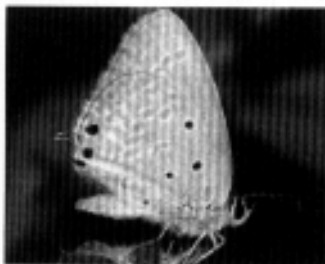
Very common, dull purple-blue above with a thread-like dark border; pale brown or grey below with the arrangement of spots on the margin. This is a very destructive species as its caterpillars feed on lime and pomello. Fond of sunshine and flies low over grass, settling on flowers occasionally



Limeblue

9. Gramblue (*Euchrysops cnejus*)

These are tailed butterflies, sized 25 to 33 mm; pale violet-blue above; dark narrow outer borders, two black spots on the upper hindwings. Strong flier, can fly high, fond of settling on flowers and suck nectar for long periods of time. Can be seen drinking from damp patches and basking with their wings half open in the sunshine. This is a minor pest of gram crops in South India.



Gramblue

10. Silverline (*Spindasis sp.*)

A tailed butterfly with a liking for the cold ashes of wood fires, burnt grass, etc., the larvae are attended by ants. Found commonly on coxcomb plants. Forewings with black-spotted orange bands.



Silverline

FAMILY Papilionidae commonly called Swallow tails

They are the largest and the most magnificent of Indian butterflies. The predominant colour is black or dark brown with additional markings, varying both in colour and pattern. The wing shape is also variable, but generally both the wings are long and narrow and many of them have tails; hence the popular name.

Eggs are spherical, smooth, or sometimes pitted laid on top of leaves of young shoots; white or green caterpillars are conspicuously coloured with a curious two-branched cylinder called Osmeterium which can be darted in and out for the purpose of disseminating scent. They are brightly coloured to warn enemies that they both taste and smell unpleasant

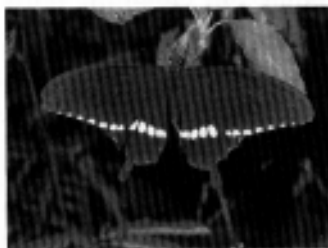
While the larvae are all protected by an unpleasant taste or smell, this form of defence is retained in the butterfly stage by two different groups only — the Bird Wings and the Red-bodied Swallow tails. The methods of flight are varied, ranging from soaring above tree tops, flitting quickly from flower to flower, lazily flying in an irregular manner to fast and straight flight. Their principal food stuffs vary from custard-apples, oranges, lemon, to parsley, etc.

The largest butterfly found in India — Southern Bird Wing — is a member of this family (however not found in RV).

THE DIFFERENT GENERA

- | | | |
|--------------------------|---|---------------------------|
| 1. Crimson Rose | } | Red-bodied swallow tail |
| 2. Common Rose | | |
| 3. Common Mime | | |
| 4. Blue Mormon | } | Black-bodied swallow tail |
| 5. Common Mormon | | |
| 6. Common Banded Peacock | | |
| 7. Common Lime | | |
| 8. Blue Bottles and Jays | <div style="display: inline-block; vertical-align: middle; margin-right: 10px;"> <div style="border-left: 1px solid black; height: 20px; width: 10px; margin: 0 auto;"></div> <div style="border-left: 1px solid black; height: 20px; width: 10px; margin: 0 auto;"></div> </div> | Common blue bottle |
| | | Tailed jay |

The Red-bodied swallow tails are a genus of unpleasant-smelling, bad-tasting butterflies, whose larvae feed on species of *Aristolochia*. Most of them bear tails, and there is always some form of red or yellow marking on their bodies and wings. They are all fond of settling on flowers — *Duranta* being one of their favourites. They can be seen flying even in a copulating state.



Common mormon male

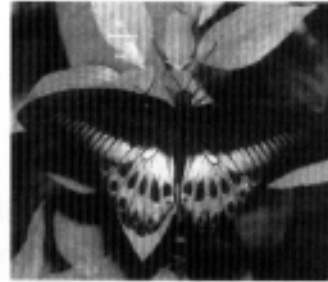
The crimson rose (*Pachliopta hector*) and the common rose (*Tros aristolochiae*) are mimicked by different forms of the female of the common mormon. The coloured plates help in identifying the butterflies.

Common mime (*Chilasa clytia*) is not a tailed swallow tail and it mimics the common crow (*Euploea core*).

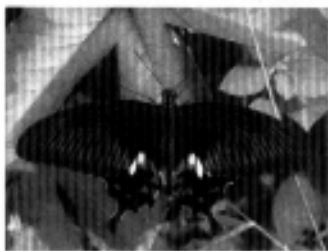
Black-bodied swallow tails (*Papilio*) are a large genus and have some of the most beautiful of all butterflies. The mormons and the peacock are tailed, whereas the Limes are not. The Blue mormon *Papilio polymnestor* is the second largest butterfly seen on the Southern Peninsula and therefore the largest seen in RV.

Their flight is strong and they usually keep to the sunshine, flying well above the ground between the branches of trees.

All of them drink freely of the nectar of flowers and some of them settle on damp mud and wet roads. The Common Mormon *Papilio polytes* mimics members of the genus *Tros* and, depending on the population of *Tros*, the mimicking pattern can vary. It is generally the female of the Common Mormon that exhibits three different patterns during its mimicry and can be distinguished from the *Tros* by the body colouration alone.



Blue mormon



Common rose

The common lime *Papilio demoleus*, as the name implies, is a pest of the lime tree, its caterpillars feeding off the leaves of the lime plant. The food plants of the great majority of the species belong to the family Rutaceae (citrus fruits) and Rubiaceae (*Ixora*, etc.)

Common banded peacock, *Papilio crino* is yet another beautiful butterfly seen in Rishi Valley.

FAMILY Pieridae

1. Whites - Psyche
2. Jezebels
3. Gulls
4. Indian Orange Tip

White orange tip
 Yellow orange tip
 Crimson tip
 Great orange tip

5. Wanderers

Common wanderer
 Pale wanderer

6. The Yellows

- a. Emigrants

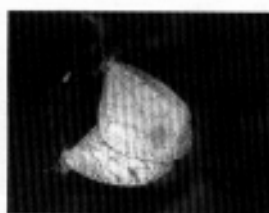
Common emigrant
 Lemon emigrant

- b. Grass yellows

Common grass yellow
 Small grass yellow

General Features

These are butterflies of moderate size, and in colour nearly always having white or some shades of yellow or orange with black markings. This family may be divided into two groups — the Whites and Yellows but these names are only a general indication of the predominant colours and each group may contain exceptions. The eggs are tall, bottle-shaped and ribbed on sides, white in colour, changing to yellow or orange sometimes with shades of red. Many of the species lay their eggs in clusters, but some lay them on the upper part of a leaf or shoot as single eggs. The whites mainly feed on Capparaceae (*Capparus*, *Gynandropis*) plants whereas yellows prefer Leguminosae (*Cassia*, clover, peas, etc.). They are sun-loving insects and are fond of the company of their own species, and can also be seen sitting on damp patches.



Psyche

Psyche (*Leptosia nina*)

A common butterfly, white in colour with a black apex and a large black spot on the upper side of its forewing. Weak flier and feeds on capers.

Common jezebel (*Delias eucharis*)

Large butterflies easily identified by the black, red and yellow markings on the underside of the hindwings. The upper side is white, with the veins blackened or blackish with yellow markings. They are usually seen flying high round trees and shrubs close to their food plant which is *Loranthus*, a parasitic plant.



Common jezebel



Common gull

Common gull (*Cepora nerissa*)

White above with some veins blackened and a black terminal border on the forewing. The border might bear white spots. Hindwings are pale or dark yellow with veins outlined in blackish-green. Its larval food is the *Capparus* sp. and the butterfly breeds wherever its food-stuff is found. It can be seen throughout the year; as it is fond of settling on flowers, it is easy enough to catch.

Indian orange tip

The Indian orange tips and the crimson tips are butterflies which are generally white in colour with the tips of their forewings variously coloured, from yellow to orange to crimson. These colourations and the sizes help identify these butterflies which are beautiful and colourful to look at. Food plants belong to the family Capparaceae; fond of feeding from flowers and drinking from damp patches.



White orange tip



Common wanderer

Wanderers (*Parenonia* sp.)

Large butterflies, the males are pale blue with black borders and dark veins. The pattern of the veins and shades of blue help differentiate the different wanderers. The female mimics the Blue tiger. Food plants are capers. Their flight is swift and fairly high.

The Yellows

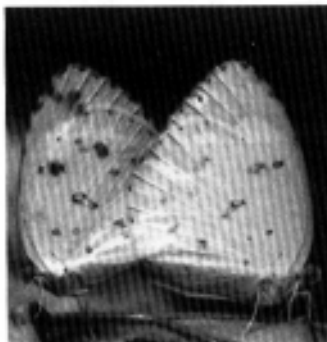
(a) The Emigrants are large, yellowish white, fast flying, sun-loving butterflies, their forewings and hindwings show black or other markings at the terminal ends that can vary seasonally. These butterflies migrate in large numbers when their food plants become scarce. Their larvae mainly feed on species of cassia. In the Common emigrant, the male is sulphur yellow, whereas the female is more whitish. Antennae are black. The upper side of the hindwing has terminal black borders.

The Lemon emigrant differs due to the presence of silvery red-ringed spots near the wing edges.



Common emigrant

Grass yellows



Grass yellow

Six species of grass yellows are found in India. These are small, fragile insects, bright yellow with terminal and apical black markings.

They can be seen fluttering among grasses and low bushes in grassy places — hence the name. Active during sunny mornings and late afternoons.

Larval food plants are the species of Leguminosae.

Small grass yellow: *Terias libythea* (*Eurema brigitta*).

Common grass yellow: *Terias hecabe*, feeds on *Cassia*, *Albizzia*, *Caesalpineae* and *Acacia*.

FAMILY Hesperiiidae

Generally called skippers, these are small insects, nearly always dark brown in colour and generally spotted with white or yellow transparent markings. Many of the butterflies can be identified to belong to this group, due to the curved or hooked antennae.

Very swift flying insects primarily of the jungle region; few are seen on open plains. Many of them are crepuscular in habit, some found flying during the night, too.

Awls

One of the few species found in the plains. Dark brown above; unmarked. Forewing with two fairly large semi-transparent yellowish-white discal spots. Hindwings dark brown, more or less glossed dull blue.

Common banded awl — *Hasora chromus*.

Common red eye — *Matapa aria* (40 to 55 mm)

Chocolate brown above, unmarked hindwing fringe grey or pale yellow. Hooked antennae, crepuscular, found near bamboo clumps.



Brown awl

The Moths

Of the 140,000+ sp. of Lepidopterans only 15% are butterflies, the rest are all moths. Found in almost all habitats and niches, they show specialised behaviour in several areas. They are indicators of areas of endemism and respond rapidly to disturbances in the environment. Refer to the coloured plates for some of the common ones seen. We give descriptions of just a couple of them from each family.

Generally Moths can be identified by the following features:

- Antennae are paired, many-segmented and often scaled. These may be filiform, pectinate (uni, bi or double), ciliate, setose ciliate, lamellate, fasciculate or combinations of the above. These features serve also to distinguish males from females. In some of the families of the moth, the antennae is usually kept tucked under the head giving their body some strange shapes.
- Mouth parts are atrophied in several adult moths and where present usually comprise of: Proboscis, which is a highly modified maxillae — in sphingidae these may be longer than the body of the moths; in some atrophied, maxillary palps and labial palps.
- Thorax is closely fused and the segments difficult to study. Each part of the thorax (pro, meso and meta) carry a pair of legs.
- Mesothorax bears the forewings and the meta thorax the hindwings.

- Presence of tympanum on the meta thorax is a feature used for identification; (Family Notodontoidea and Noctuoidea) Geometrids carry the tympanum close to the first spiracle.
- Ninth and tenth segments of the abdomen are fused to form the genitalia. Genitalia is an important structure for identification.
- Erectile hair tufts are seen in the male of many sp., and are held folded, often being unnoticeable. Some species, Arctiids, have large, thin, walled structures called coremata for scent production.

FAMILY Cossidae

This family consists of the most primitive moths and are commonly referred to as goat moths. It is so called because of the goat-like smell emitted by its caterpillars. The typical goat moth is a sturdy moth which will resemble a stout dry twig when at rest. It's dull, grey-brown in colour, and keeps its antennae tucked under its body. Its caterpillar is a wood borer.

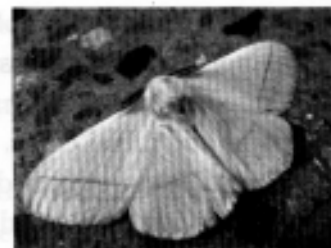


Phalera sp.

Another moth belonging to this family is white and hairy with black dots/speckles all over. It's called the leopard moth. Of the same size as the goat moth, its abdomen can be seen extending beyond the wings. The thorax is unmistakably hairy, prompting some young children at Sahyadri School, Pune to compare it with a Pomeranian.

FAMILY Eupterotidae

This is a small family of moths found predominantly in Oriental and African regions, and are basically moths of the Old World. The wings are large relative to the body size, the forewings are deeply triangular (have a rounded, right-angled tornus) which is an identifying feature of this family, whereas the hindwings are almost circular, but both wings are equal in size. The scales of the wings are both deep and coarse. The frenulum and retinaculum are either weak or sometimes absent. The antennae are evenly bipectinate and broad in the male, whereas they are not so strongly seen to be like that in the female. The larvae of the *Eupterote* genus feed on a wide



Monkey moth

variety of plants of economic importance. Thus they come under the category of pests. They are commonly referred to as monkey moths.

FAMILY Saturniidae

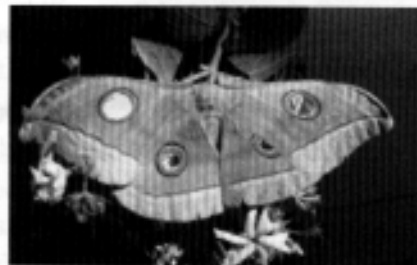
Saturnids are found worldwide although their diversity is most in tropical countries. The moths belonging to this group are so decorative that they are highly prized by collectors around the world. Their most characteristic marking is the discal ocelli seen on both wings. The pattern on their forewings and hindwings is similar. The larvae are large and coloured. Many of them have horns dorsally and laterally. Dense silk cocoons are spun during pupation.



Atlas moth

Atlas moth: This is an example of a saturnid moth and is the largest one in Asia. the adult moth does not feed, living for 2 or 3 days to 2 weeks to mate and lay eggs, after which it perishes. It can be seen with the onset of the southwest monsoon when the pupa hatches. It is so called due to its wing pattern which resembles maps. Look at the wing tips. They look like a snake's head. This is mimicry to keep predators away.

Tasar silk moth: A beautiful moth whose larvae feed on the Singapore cherry plant. This moth can be seen in different hues depending on the vegetation where it is seen. Its pupa looks like a round yellow nut, and is sometimes brown in colour. These can be seen on *Duranta* bushes.



Tasar silk moth

FAMILY Sphingidea: Hawkmoths

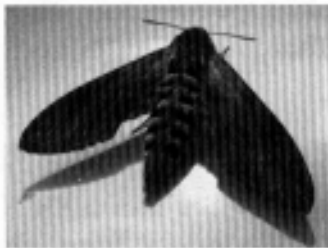
Some taxonomists consider this family to be a part of the family Bombycoidea. A large family of moths that show amazing colour and variety. Narrow pointed wings is a good pointer to identification, and most of them are large moths in terms of length. Their head region which contains their mouth parts is shaped like a hawk, which gives them this name. Caterpillars have horns on the dorsal side.

Hummingbird hawkmoth: As the name suggests this moth shows a behaviour similar to the hummingbird, as the adults feed on the nectar from plants. They make a feeble hum as they fly to feed. Although a day-flying moth, it is seen generally towards the dusk, feeding off the plants while still in flight, their long coiled proboscis uncoiling and reaching into the depths of the tubular corolla to extract nectar. You can spot them easily on *Petunia* flowers. Seen during the months after the southwest monsoon has receded.

Death's head hawkmoth: This hawkmoth gets its name due to the markings seen in its head region which resembles a skull. Its hindwings are yellow and black as are its segments. It does not feed on flowers much but can raid beehives for honey. This moth is quite noisy if captured and the sound it produces resembles the call of a bird, the flowerpecker.



Death's head hawkmoth



Convolvulus hawkmoth

Convolvulus hawkmoth: This hawk moth's wings are grey to dull sand colour, but the abdomen has pink coloured segmental bands alternating with the dry colour. Seen in the evenings and particularly during the months of January to March, the larvae feed on *Ipomea*, whereas adults feed on *Petunia*. However in the Sahyadri range these moths could be seen during September.

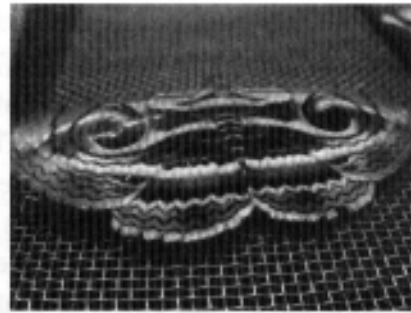
Oleander hawkmoth: We have used the name 'Tabernaetum moth' to identify this moth whose caterpillars gorge on the leaves of the plant *Tabernaetum*. This brightly coloured (green and cream) moth can be seen from July to November. Its caterpillar is also spectacularly green in colour with two large purple eye-markings. The caterpillars can be reared to study metamorphosis. It breeds profusely. The adult moth feeds off the white flowers. The adult has been seen on *Nerium* too.



Oleander hawkmoth

FAMILY Noctuidae: Owlet moths

These are robustly-built moths that constitute the largest family in the Lepidoptera. They have some fine colours in their hindwings, but sombre forewings. At rest the wings are held vertically sometimes but most of the times that we have observed, flat and overlapping. Most of noctuids fly at night and are almost invariably strongly attracted to light. Many are also attracted to sugar and nectar-rich flowers.

*Spirama retorta*

Some of them are preyed upon by bats. But the noctuids have tiny organs in their ears that responds to bat echolocation calls which helps them to avoid the bats.

FAMILY Arctiidae: Tiger moths

Tiger moths get their name from the bright colours of their hindwings: the colour along with the dark lines resemble the colouration of the tiger and hence the name. The forewings are rather dull in comparison. The moths sit with their wings closed, the bright coloured hindwings generally displayed to cause surprise and scare possible predators. They are small to medium-sized moths that hold their wings rooflike while at rest, or horizontal over the abdomen. These moths are generally distasteful to predators. The presence of a pair of glands, possibly pheromonal, dorsally and anteriorly between the ovipositor lobes is a defining characteristic of this family. Tiger moths, footman moths, wasp moths, etc., belong to this family. Footman moths are also bright, usually small and slender. The larvae are very hairy and are often referred to as 'woolly bears'.

fruit piercing moth *Eudocima materna*

Female tiger moth with eggs

FAMILY Geometridae:

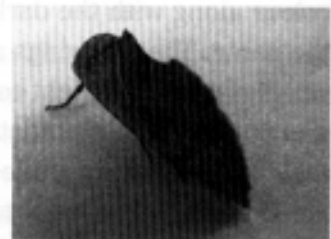
The famous peppered moth studied by biology students belong to this family. They are also called looper moths because the caterpillars move by curving their bodies into loops. They are also referred to as inchworms and twig caterpillars because the terms describe the caterpillar's behaviour. These caterpillars have only one or two prolegs. The adults are medium to large size; active at night, they have camouflaged wing patterns that are usually wavy lines extending across both fore and hindwings. The resting position is a standard posture, holding wings outspread, tightly pressed against the surface on which they are sitting. This ensures that no shadow is formed and the wings outline well offering a better camouflaged posture. Note the way antenna (similar in colour) is held.



Comostola sp.

FAMILY Notodontidae: Prominent moths

The characteristic feature of these moths is their shape when resting: a tuft of (hairy) scales on the rear of the forewing gives them a prominent hump while they rest which helps in recognising this moth. Vein patterns on the wings and characteristics of male genitalia are features for identifying them. (Vein 8 of the hindwing is connected to 7 near middle of cell.) Proboscis present.



Lappet moth

Buff tip is a common moth noticed that belongs to this family. It is so well camouflaged that you would invariably mistake it to be a piece of bark or a thick twig of a tree. Their legs are quite hairy and look stocky.



Burnet moth

FAMILY Zygaenidae:

This family consists of moths which are commonly referred to as burnet moths and slug moths. These are brightly coloured day-flying moths characterized by long clubbed antennae. They are brightly coloured, many of them red in colour.

ORDER: COLEOPTERA

The word has its origins in a Greek word which means 'sheath wing'.

The word and its description are a reference to the armoured forewings called 'elytra', a characteristic feature of this group consisting of insects commonly called beetles.

The elytra is hard or leathery, and when kept folded meet in a straight line down the middle of the back, protecting the membranous hindwings that are used for flight.

Although all beetles can fly, most do so only for very short distances. With a well developed mandible, they are the most destructive group of insects and, yet, has an important ecological role going beyond just destroyers or pests. It is very difficult to generalise about beetles as they come in different shapes, sizes, colours and can be found practically everywhere — from stored grains in kitchens, to troubling us on rainy nights, swimming in water, buried amongst the debris, to say nothing about their presence on plants.

Their variation in antennae shapes as well as body shapes can be of some help in learning to identify them.

We have confined our descriptions to some of the more commonly seen ones. Therefore all the families belonging to Coleoptera do not feature here. (See Plates on pages 9-13.)

The two suborders that are featured here are Adephaga and Polyphaga.

Adephaga: Hunters and carrion feeders, they include tiger beetles, ground beetles, water beetles and whirlgigs; a few families are explained below.



Cicindela sp

FAMILY Cicindelidae: Tiger beetles

These are often a brightly coloured brown, black or green with conspicuous yellow, or white spots and bands. They are slender-bodied, long-legged insects that are good runners. These are fierce predators and have a sickle-shaped mandible that can nip sharply. The eyes are prominent, antennae long and the head constricts behind the eyes into a neck. About 20 mm in length. Abundant during the rains. Immature ones live in burrows.

FAMILY Carabidae: Ground beetles

Abundant in all habitats. Nocturnal predators, they can be seen under moist logs, leaf litter, and on rocks during the day. Dull brown, black or dark blue, they are, as the name suggests, ground dwellers. Antennae filiform, all tarsi jointed. The famous bombardier beetle belongs to this family. This is a large family with over 25,000 species worldwide.

Anthia sexguttata or six white-spotted beetle is the largest one from this family.



Ground beetle

FAMILY Dytiscidae: Diving beetles

The adult and larvae are aquatic. Elongate, oval and convex, they can be seen on lilly ponds and garden pools; they are voracious feeders whose prey range from small fish and tadpoles to frogs. Their hind legs are modified as paddles. The adults trap air beneath the elytra before diving into water and rise to the surface when they run out of air supply. Antennae threadlike.

FAMILY Gyrinidae: Whirlgigs

Small, shiny black beetles; gregarious, swimming rapidly round and round (gyrating) in circles that look like a complicated formation; elongate, oval and flattened. Disturb them and they promptly dive down, carrying a bubble of air with them. They are typically seen in warm, tropical fresh water.

Polyphaga: Largest suborder of beetles with about 149 families worldwide.

FAMILY Hydrophilidae: Water scavengers

Only one species has been noticed. Small, black and brown, five-spotted beetle, common in tanks.

FAMILY Staphylinidae: Rove beetles

They have a short elytra, leaving much of the abdomen exposed. They have a tendency to curve their abdomen when handled. Generally detritus feeders or predators, some are phytophagous. Some of them can be mistaken for earwigs. But these lack the curved cerci seen in the latter.

Paederus fuscipes is a common black and red species that comes out at night, and is reported to cause mild blisters on human skin. They are sometimes referred to as 'spider-tick'.

FAMILY Lampyridae: Fireflies



Firefly showing light producing organ

These are not as hard as the typical beetles. The fireflies that emit light in flashes and with which one is familiar are males with wings. The females are wingless and look like a larva. They are commonly called the 'glow-worm'. They are usually brown or red in colour. Posteriorly, on the ventral side of the abdomen are the light producing parts. They are nocturnal and predaceous often feeding on land snails. The flashes of light produced by the male insects are 'codes' to be deciphered by the females and the pattern of flashes vary in different species.

FAMILY Buprestidae: Wood borers

Also called 'jewel beetles'; brilliantly coloured and diurnal, *Sternocera* species is common in India. Its elytra is brown, whereas the thorax is an iridescent metallic green or blue. Prosternal process extends into a mesosternal cavity. Antennae serrate and short; tarsi 5, jointed. Lays its eggs in the soil close to trees. The larvae tunnel into tree trunks and pupate in this larval tunnel. The elytra is used in embroidery and as inlay in jewels in India, China and Japan.

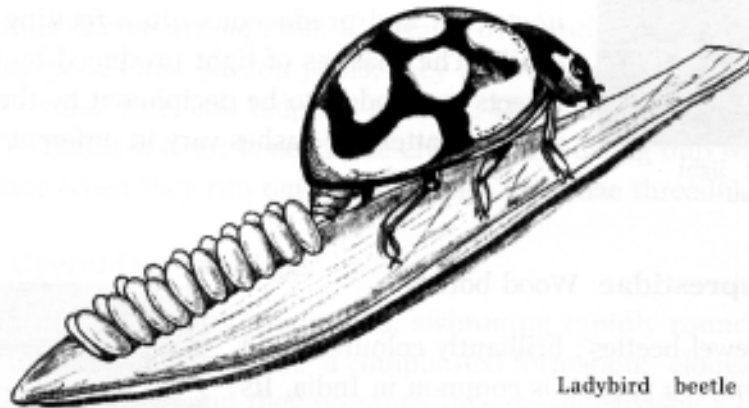


Sternocera laying eggs

Chrysochroa sp. also belong to this family. They are bright green beetles with an elongated body often mistaken for click beetles. The metallic green has a red reflection at the margin of the elytra. Antennae serrate and short; tarsi 5, jointed. About 17 species can be seen in India. These are often collected to be sold as curios.

FAMILY Coccinellidae: Ladybird beetles

A large family of small, hemispherical, shiny beetles — yellow, brown, pink or red, often marked with black stripes or spots. There are two groups of ladybird beetles, the plant feeders and the predators. The plant feeders have large toothed mandibles and include the genus *Epilachna* that breed on brinjal, potato and cucurbits. The common carnivorous ladybird beetles we are familiar with belongs to the Genus *Menochilus* sp. The elytra is red in colour with seven black spots, and the prothorax is black. This is an important predator of aphids. Some of the coccinellids are known to migrate during autumn from plains and valleys to high mountains.



Ladybird beetle

FAMILY Elateridae: Click beetles

Generally black or brown but sometimes metallic coloured. When it falls upside down on its back, it has the ability to jerk itself up with a click. That has earned for them the name click beetle. Along with the click, it also manages to jump back onto its legs some distance away very quickly. Its larva is called 'wire worm' and can cause harm to crops. A metallic green species is seen commonly at Rishi Valley.



Click beetle

FAMILY Pyrochroidae:

They are all bright, scarlet or red in colour with serrate or pectinate antennae. Small to moderate size, their beautiful scarlet elytra gives them the name as 'fire-coloured beetles'. They are found on flowers and vegetation. They are not very common in Rishi Valley. *Pyrochroa* sp. is the common genus to be seen. It has a toothed antenna and pubescent body.



Blister beetles

FAMILY Meloidae: Blister beetles and oil beetles

The commonly seen oil beetle is shown in plate 9. It yields cantharidine. This is a clear, pale-yellow, oily liquid exuded by beetles from the joints of their legs.

In the case of blister beetles, the liquid exuded can cause blisters on human skin and hence the name blister beetle. Extensively found in large numbers, closely stuck to the stems of the *Ipomea* plant, the red beetle with black markings seen in Rishi Valley and other places are referred to as blister beetles. The actual blister beetle shows not red but yellowish-orange markings.

FAMILY Tenebrionidae: Meal worms

Black beetles common in dry localities. In several species the elytra are rigidly soldered together and the beetles cannot fly. Ranges in size from 2- 3.5 mm. Many of them are pests of stored products, whereas some of them occur under stones, trees, tree bark, rotten wood, etc. Most species are nocturnal and scavengers. Some of them are ant-loving (myrmecophiles). *Tenebrio molitor* is the meal worm found breeding in stored flour, and it is the larval stage of beetles. *Tribolium castaneum* is the red flour beetle, and one can look out for them in pulses and other stored grain in a kitchen.

FAMILY Cerambycidae: Longicorn or Longhorn beetles

Longhorn beetles named so because of their long, swept-back antennae. This feature, combined with their brilliant colours, makes them popular with collectors. The vast majority of species in this family have antennae that are at least half as long as their elongated cylindrical bodies, and may be up to 3 times the body length which itself measures 6 to 7.5 mm. Most of them bore into live trees when they are in their larval stages. Very few bore into felled/dead trees. *Acanthophorus* is a large beetle that breeds in many trees. *Stromatium* tunnels into babuls or katechu (*Acacia*) trees.



Longicorn beetles

FAMILY Chrysomelidae

Over 40,000 species are known, ranging from 1 to 20 mm and are rarely over an average of 12 mm. Body is generally oval.

The Tortoise beetle, *Aspidomorpha* sp., is a common one that is shown on plate 11. This was earlier a member of the family Cassididae, but now is classified under this family.

These are very interesting beetles whose prothorax and elytra are convex and together form a transparent shell which is so wide that only the tips of the walking

legs can be seen. This whole covering resembles a tortoise shell and hence the name. These come in brilliant colours and are for the same reason collected; however the coloration is a combined effect of pigment and light refraction by the chitin. Hence the coloration is lost when they are dead. Feeds on leaves of Convolvulaceae (*Ipomea*). Another colourful beetle shown here is *Sagra femorata*, common throughout India.



Cassida circumdata



Staghorn beetle

FAMILY Lucanidae

Members are called the 'staghorn beetles' because the males have enormously developed mandibles which are armed with teeth, the whole structure resembling the antlers of a deer. The female is much smaller and quite unlike the male in appearance as it lacks the antlers. Their antennae are elbowed and end in three enlarged fan-like segments. The larvae breed in decaying roofs or wood, and take a long time to mature. The commonest staghorn beetle of South India is a reddish brown to black-coloured beetle, *Cladognathus giraffa*.

FAMILY Scarabaeidae : Scarab and dung-beetles

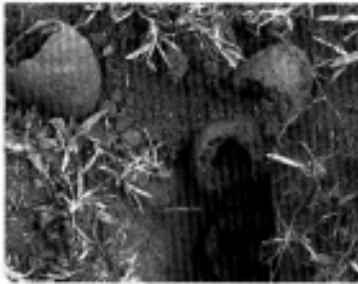
(Read about the Scarab in the third chapter of this book titled, 'Insects In Our Culture'.)

The most familiar of them is the dung roller beetle; the scarabs are robust, smooth and shiny black beetles. They may be observed on open grounds busily and tirelessly rolling neat balls of herbivore dung laboriously over great distances. They do this by pushing the ball backwards, holding and rolling it expertly between the hindwings. Sometimes you find two beetles working together, one beetle pushing

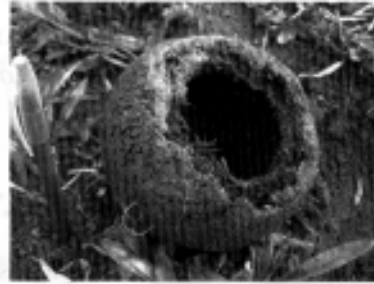


Gametes versicolor

backwards and the other dragging the dung ball, co-operating marvellously to speed up matters. These are eventually buried underground in a chamber dug by the insect; here the dung is divided into two parts — into one, a small space is created into which an egg is deposited. The other part is used as food by the beetle. There are several types of scarab beetles.



Elephant dung-roller balls



A single ball prised open by bears

Heliocopris bucephalis is the common dung beetle that can be seen feeding on elephant dung in the forests. The accompanying image is the dung ball of the beetle that has been prised open by a bear to feed on its larva.



Bear pug maks on an elephant dung-roller ball



Onthophagus hystrix

***Onthophagus hystrix*:** Not all scarab beetles feed on dung. Some of them gather carrion of dead snakes, lizards, grasshoppers, millipedes, etc. Therefore their role in our soil ecosystem cannot be

underestimated. *Onthophagus* is one such dung beetle found in India. It is 3 to 4 mm long.

Another remarkable feature of the scarab beetle is the most striking sexual dimorphism. Strange and incredibly grotesque forms of horns, tubercles, ridges

and other types of head armature grow on the shovel-like head and prothorax in males. This will help identify beetles as scarabids.

Some of these beetles are brilliantly and metallic coloured. Some commonly seen beetles are shown in the coloured plate 12.

Oryctes rhinoceros is the common 'rhinoceros beetle'; it is so called because the head bears a stout curved horn in the middle as in the rhinoceros. The females do not have horns. Look out for it during the rains or soon after the rains.



Rhinoceros beetle



Rose chafer

A variety of beetles called 'Cockchafers', 'Leafchafers' and 'June beetles' were earlier referred to as scarab beetles. Leafchafers that are blue, green and golden in colour are all found in the Valley. The illustration here is of a flower beetle commonly called the June beetle. Cockchafer beetles come in different sizes and in brilliant metallic colours with tubercles, crests or horns on their heads. Some of them are large, reaching a size of 65 mm. The well known goliath beetle is a member of this family.

FAMILY Curculionidae: Weevils

Weevils form the largest animal family. *Rhynchophorus sp.* are snout beetles commonly called weevils. Their rostrum is formed by forward prolongation of the head which looks like a beak or a snout. Hence the name. The tip of the snout bears the mouth parts and the antennae, and this is how they are distinguished from beetles and identified as weevils.



Weevil

True weevils have elbowed antennae. The red palm weevil is a common destructive pest of the coconut. Many of these weevils can be observed on the Calotropis plant (common milk weed). Weevils are quite destructive and hence have been extensively recorded by agricultural entomologists.

ORDER: HYMENOPTERA**(Membranous wings)**

Ants, bees, and wasps

This order of insects comprises saw flies, ants, bees, wasps and ichneumon flies. The ecological significance of hymenopterans cannot be overstated. While humans regard wasps with dread, it should not be forgotten that they are the primary agents of insect population control. Similarly ants aerate and fertilise the soil recycling soil nutrients as efficiently as earthworms. Hymenopterans are the major pollinators of flowering plants with as many as 150 crops throughout the world being pollinated mostly or entirely by bees which at the same time, provide us with honey. Hymenopterans possess two pairs of more or less transparent membranous wings which are usually narrow and in some cases with very few veins; the hindwings are smaller than the forewings. A large proportion of them have a narrow waist. The base of the abdomen is constricted and sometimes distinctly stalked; the thorax contains a fourth segment — the propodium which is nothing but the basal abdominal segment fused to the thorax (often referred to as wasp-waist). Their mouth parts are formed for chewing, lapping and licking, in which the labium and maxillae are modified into a tongue-like apparatus for drinking. They all undergo complete metamorphosis. All the females have an ovipositor which in the case of bees, wasps and ants also serve as the sting.

Entomologists consider them to be the most advanced among insects due to their highly specialised nature. Ants and some families of wasps and bees have evolved a co-operative social hierarchy in which there is a division of labour among different castes. Thus there are workers, soldiers, queen/s and occasional males. Workers are sterile females who nurse the eggs and larvae, and maintain the nest, whereas those which guard and protect the nest are soldiers. The few males of the colony exist only to mate with the queen, the only member of the colony to lay eggs. The hymenopterans along with Termites that belong to the order Isoptera are the architects of the insect world.

Some families of wasps, bees and ants are described in the following pages.

WASPS

FAMILY Cynipidae

Commonly called gall wasps, these are minute, blackish, brown or yellow insects that produce small outgrowths called 'galls' on plants. Some of them are parasitic on dipteran flies.



Gall wasp



Leaves with galls

FAMILY Ichneumonidae



Ichneumon

Ichneumonidae is the largest family of wasp species. Ichneumon wasps are slender-wasps found at Rishi Valley but they are not as common as braconids. They are attracted by white light. You can see them at night on white outside walls of buildings. Generally

yellow to black in colour and brightly patterned with brown and yellow, they have a long ovipositor. Many of them do not sting; are excellent pest controllers of caterpillars that play havoc with our crops. The larvae of these insects, parasitise the larvae of beetles, moths and butterflies.

FAMILY Braconidae

Braconid wasps are brightly coloured. Their heads are large, distinct with moderately long antennae. General form varies. Can be distinguished from ichneumoids by wing venation. Their larvae are parasites on a great variety of insects. They are very important in insect pest control. The pupae of these wasps can be seen as white cocoons deposited under the bark of trees. *Peltophorum* and Tamarind are some of the trees on which these wasps cocoons can be seen.

FAMILY Evaniidae

Evania sp. is a medium-sized insect easily recognisable by its flag-like abdomen which extends from a slender, stalk-like (petiolate) part that is attached to the stocky, thick thorax. Antennae are filiform. Black in colour, they deposit their eggs in the egg capsules of the cockroaches. The larva as it feeds destroys the eggs, keeping a check on cockroach populations.

*Evania sp.*



Fig wasp

FAMILY Aganidae

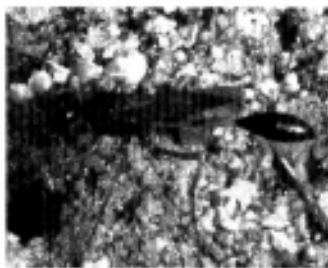
Once called 'Chalcid wasps', this family holds the famous fig wasps, the only insects that can pollinate the figs. They are generally minute (5 mm or less). The female is a normal insect, while the males are mostly wingless. The males' only tasks are to mate with the females while still within the fig, and to chew a hole for the females to escape from the interior of the fig fruit. Forewings with a single vein is one of the features for identifying it as an aganid.

FAMILY Chrysididae

The members of this group are commonly referred to as 'cuckoo wasps'. These are a remarkable group of bright, metallic-green or sometimes metallic-blue wasps. Their activity begins from the month of March in the plains and can be seen invading our houses too. When disturbed, the adult wasp rolls itself up into a tight ball with its head inside and remains motionless, pretending to be dead. They are called cuckoo wasps because of their curious habit, like the cuckoo bird, of smuggling their eggs into the well-provisioned brood nests of solitary hornets, wasps and bees.



cuckoo wasp



mud dauber wasp

FAMILY Sphecidae

This family's most common wasps are the mud daubers that make nests out of mud in our houses, in the furniture, walls, keyholes, etc.; they provision their brood nests with spiders, grasshoppers, flies, caterpillars, bees, etc., as food for their future larvae. They first tranquilise the victim by stinging it, and then transport the immobilised prey to the brood nest.

Some of the common members are described below:

Sceliphron madraspatanum is a mud wasp which is black and yellow in colour. As mentioned above, it has a thin, long waist. Its nests are shaped not like pots but are cylindrical, and look untidy when finished. This is because the wasp camouflages its nest; after making perfect pots it completely covers them with mud so that the whole structure looks like a slab of mud.

Chelybion benghalensis

This is another kind of thread-waisted mud wasp whose body and legs are shiny blue in colour. The head is brownish-black and the wings are copperish brown. This wasp builds its nest by filling lime or plaster into the sockets of electric plugs. It can be seen active from February onwards in the hot plains for most part of the year. It was also seen to break open the nest (see accompanying image) made by another species of mud wasp and use the space to raise its own colonies.



Chelybion benghalensis

Another mud wasp that collects its material from wet clay soil for building its nest has a body and legs that are black and orange in colour and has a slender waist. There are at least two more thread-waisted wasps that are seen in RishiValley that are yet to be identified. These species are common enough in our gardens and in our houses, and can be studied without any harm to oneself.

FAMILY Scoliidae

Commonly called scoliid or digger wasps, their bodies are generally black and yellow. The scoliid wasps found in the Valley look like bees; they have yellow abdomens with black stripes across the segments. The female wasps dig the ground in search of prey which is then stung, and pushed into a hole; an egg is then laid in the hole, after which the hole is closed up.



Spider wasp (*Pepsis* sp.)

FAMILY Pompilidae

Commonly known as the 'spider wasps', these are medium to large-sized wasps with long legs and bright colours. Wasps seen in the Valley have a blue body with rust-coloured wings that are long and cover their entire abdomen. The wings are held folded flat above the abdomen.

These are seen in the months of August - September, and a similar wasp seen from months of December onwards has metallic-blue wings. It is not known whether they are a single species with

seasonal variation in colour or two different species. They are seen generally carrying spiders or crickets after paralysing them to put into their underground tunnels. They lay their eggs and then meticulously cover the hole, taking care to leave the soil as it was before their digging operation had started. We would strongly recommend wasp-watch as an activity for nature lovers for it is a revelation in many ways to see these industrious and clever wasps making their nests, bringing their prey and hiding the hole by landscaping the soil to make it look as if there was no digging done at all.

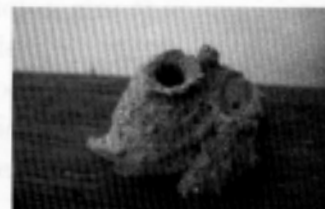
FAMILY Vespidae

This family now includes Yellowjackets, Paper Wasps, and Hornets, Potter or Mason and Pollen Wasps. Thus this family has both social and solitary wasps. A few of them are described below. The cover of this book features a unique Hornet's nest which we found being built from the base of a Jamun tree and sloping towards the top, and in the close vicinity of the student's living quarters. More details are given under the heading: Hornets.

Eumenid wasps

Members of this group are commonly referred to as 'mason' or 'potter wasps' and they are all solitary wasps. They keep their wings folded longitudinally when at rest. They build beautiful pot- or flask-shaped nests to raise their brood. Many of them are known to rest in underground tunnels or inside hollow stems. They lay eggs, store paralysed caterpillars in these hollows, and some of them then seal the mouth of the opening with mud. Some others build nests in these hollows. Most of the species observed stored caterpillars in their nests. The *Eumenes* sp. found in the Valley is shown in plate 16: they are known to rest in underground tunnels or inside hollow stems. Some of them also build nests. The *Eumenes* species found in the Valley are shown here:

- (i) *Eumenes petiolata* Black head with yellow labium, body completely brown in colour, slender and long waist, transparent brown wings, black marks on the swollen parts of the abdomen and a black line on the thorax where the two



Eumenid wasp and its pot

wings join. Another species of *Eumenes* has almost similar markings, but the head is brown and the wing is more opaque. Both these make flask-shaped pots.

(ii) Orange and black-coloured species; it has almost the same colouration as above but has a very small waist. Clear bands of black on the abdomen.

(iii) *Rhynchium* sp. This wasp is slender and completely blue in colour. It has a waist which is short and thin. Its pots are pitcher-like, dark brown as though they have been varnished, and the cells are sticky from outside as though they are coated with a black gummy material. Caterpillars are their favourite prey.



Pots of *Rhynchium* sp.

Paper wasps

There are at least four species of paper wasps seen in Rishi Valley (and we presume) as well as in areas that host a similar habitat.

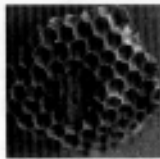


Polistes' nest

Polistes sp. The commonly seen *Polistes* at Rishi Valley is bright yellow-coloured with black lines on its abdomen; it has a slender waist and its choice of nesting places seems to be buildings and often places where there is human activity. There were two nests in our biology laboratory, one under a student's desk and another hanging from the roof of an open shelf on which was glass ware. The nest materials ranged

from plant cellulose to the pulp from files kept in the laboratory. The entire nest hangs from a stalk which attaches it to the substratum. It consists of a single more or less, horizontally circular comb of paper cells. A particular nest which we observed was more long than wide in its structure. When disturbed these wasps stand at the edge of the cells with their wings spread out (see plate 15) with a menacing look to ward off intruders. A single egg is laid at the roof of the cell, and it is the queen that initially builds the nest. Subsequently, when she has raised a brood, the job is taken over by the workers. The texture of the entire nest can be compared to thin, flaky, translucent, white butter-paper.

Ropalidia sp. Another species found here is the *Ropalidia*. One species of *Ropalidia* is greenish-brown with some parts of the thorax and abdomen yellow with black lines. Although its nest can be seen near human habitation it, also, frequently builds nests on tree branches. The nest is wide and short and the cells are smaller in diameter than those of *Polistes*. Like the nests of *Polistes* these nests also persist for a good 8 to 9 months of the year. The sting of paper wasps deliver a chemical that is quite painful and stays for a long time. When these chemicals accumulate through successive stings and reach an individual's body threshold of tolerance, then the result can be fatal if prompt medical aid is not given.

*Ropalidia* sp.Nest-*R. marginata*

The third species of paper wasp seen is *Ropalidia marginata*. These wasps are small and brown in colour, and build nests of medium size. A lot of work on this species has been done by Dr Gadagkar and his team from IISc.

This wasp also stings and, when approached, fiercely guards its nest. These also begin their activity at the start of summer and continue right through to the winter months.

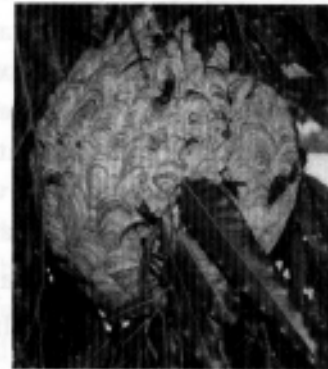


The fourth species of wasps seen in the Valley is yet to be identified. It is about 1 cm long, white and brown in colour, appearing slightly transparent. It makes small and slender nests with long pipe-like cells.

Hornets

Hornets differ from paper wasps in being bigger built; they are largely black and brown with yellow markings on the head, thorax and abdomen. Their nests are completely different from those of paper wasps as is quite evident from photographs. The cover of this book features the nest built by *Vespa orientalis* on a Jamun tree. Unlike the normal hornet's nest that appears dome-shaped, this one is more like a large pitcher. Another difference noticed was its choice of place for building its nest. While most hornets prefer to build their nests high up in the trees, this one chose to build its nest close to the ground and on a tree that was next to the wall of a building. The building activity of hornets starts in the months of February to March, and the momentum gathers in the succeeding months as the nest grows in size. The queen hornet starts the nest with a single

tier of cells and soon, as the workers are produced, these tiers of cells increase in number. Along with the cells, the hornet now produces an outer envelope to cover the cells. The materials for these building activities are obtained from the plants around. The eucalyptus was observed as the hornet's favourite tree. The nest grows in size as thousands of workers now join the building activity to produce the structure. As the nest increases in size, the envelope completely covers the nest from all sides, leaving two entrances. If one of the entrances is blocked, they make another by working from inside. Towards November the workers start taking the pupa away from the nest, and the nest is almost emptied by the time winter sets in. The few remaining workers stay around the old nest or die. The nest was built in 1993. A large underground nest of *Vespa tropica* was seen in the garden backyard of a house in Suchindrum, Tamilnadu. The nest had a single opening for the hornets to enter and exit.



Hornet and its unfinished nests

Bees

Bee-keeping being a commercial activity, a lot of literature is available on bees. Hence we have not described the honey bees. Other commonly noticeable bees observed in the Valley are described.



Carpenter bee

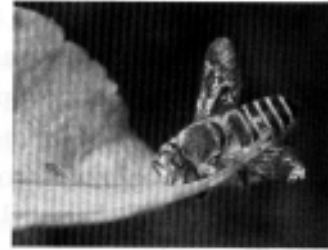
FAMILY Anthophoridae

Commonly called the 'Carpenter bees', these are large dark metallic blue bees often with yellow hairs. They get their names due to their habit of tunneling into holes, dry wood, bamboo, etc., to build their brood nest. They are successful pollinators, and can be seen active practically throughout the year.

FAMILY Megachillidae

Robust and solitary, these are called 'leaf-cutter bees'. Their pollen apparatus is found ventrally on the abdomen. Look at the picture given for the body pattern, especially, the distinct bands. It must be remembered that bands on the abdomen are also seen in members of Vespidae family. The wings are grey with black edges. They construct their nests in burrows in walls and in any kind of holes seen in doors, walls, roofs, etc. We noticed that one even built its nest inside a wooden letter box kept outside our house. They expertly cut leaves into uniform shapes and sizes and package them neatly into their burrows. As bougainvillea is abundant in the Valley, the bees often use its leaves to build their nest. It would be a very interesting activity to observe the bees lining the narrow holes with the leaves.

Belonging to this family are also the mason bee which builds cells of clay and the small metallic-green bee which nests inside hollow, dry, twigs.



Leaf cutter bee

FAMILY Apidae

These comprise the true honey bees and the Indian wild rock bee.

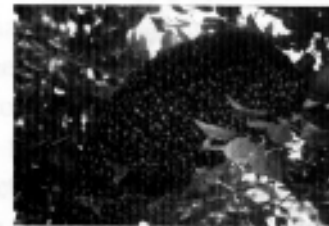


Wild rock bee

Apis dorsata is the largest honey bee and it builds its wax combs on over-hanging cliffs (in RV it can be seen in cave rock, three sisters rock and hanging from the branches of big banyan tree), large trees and tall buildings. The comb built in the big banyan was more than one metre long and three-fourth metre wide.

An interesting bee belonging to this family is the bumble-bee. However this bee is not seen in Southern India but is common in the Himalayas.

This account does not mention the language the bees use to communicate with one another, information concerning nests, and means of locating food, as this has been extensively documented.



Wild rock beehive

ANTS

The scientific study of ants is known as 'Myrmecology'. Ants are the only family in the insect world which are completely colonial and truly social. No ant can survive alone by itself far away from its colony. There are close to 12,000 species known worldwide. According to E.O.Wilson, at least twice that number remain to be discovered and studied, and these are mostly to be found in the tropics. The social life of the ant is far more complicated than that of bees or termites and presents challenging problems for the naturalist. The size and polymorphism of an ant colony are extremely variable; polymorphism attains its maximum development and complexity among ants. It has been reported that there could be sometimes twenty-one different castes in the colony of a single ant species. A colony usually contains the following castes: gynaecoid workers, capable of becoming a queen ant if well nourished; numerous workers which are sterile females; wingless soldiers who are modified workers with enormous heads and jaws armed with sharp teeth for crushing a foe; large, fertile females, and winged, fertile males.



Prenolepis sp.

The queen ant, once fertilized by the male during the nuptial flight, sheds her wings as they are useless for her. She goes underground and starts nursing her first brood of young by feeding them with a special secretion of her own saliva. During this time she does not feed but nourishes herself by breaking down and converting the now useless flight muscles in her thorax into material for her own nourishment. As soon as the worker ants appear from this brood, they go forth on forages and take over from her all the responsibilities of looking after the young ones. The queen thereafter concentrates on egg laying, and continues to lay eggs for about another fifteen years or so.



Colony of ants

Identifying Ants

Ants generally have elbowed antennae. The number of antennae segments (9, 10 or 11), whether the antennae are clubbed or not and if clubbed, how many segments form the club (1, 2 or 3) help to identify them. The abdomen (called gaster) is connected to the thorax (called mesosoma) by a segment called a petiole. This petiole can have a single node or a double node which is important for identification. Wings are present only in sexually fertile forms, but even in them the wings are cast off soon after mating.

Some commonly seen ants are described below.

Prenolepis longicornis

These are small black ants and have a single node. They are more of pests and are found near human habitation. They can be seen on damp walls, on doors, under leafpiles, and trashcans, etc. They are usually seen carrying their white pupae. They do not bite but we feel ticklish when they move on our body. The white pupae that they carry are often mistaken for food being carried by the ants. They move randomly and in a disorderly manner. These ants often relocate their nest, especially before the monsoons. They are also called 'tramp ants'.

Oecophylla smaragdina

This common Indian ant known as the 'weaver ant' makes its nest on plants by sticking leaves together. To stick the leaves together it uses its own larvae which in turn produces the necessary silken threads. The workers hold the larvae in their jaws moving them in all directions to fix and fold the leaves with the help of the silken thread. These ants are of the colour of sand and attack anyone coming close to the nest. Their attack is two-fronted as they not only bite but squirt a fine jet of formic acid, thereby adding to the irritation. It also has a single node.

In their book *Journey to the Ants*, Bert Hölldobler



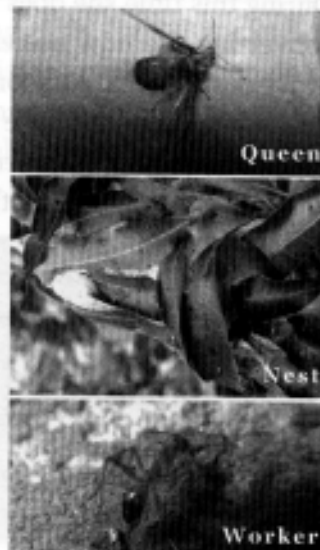
Fig 1. Petiole with single node



Or



Fig 2. Petiole with two nodes



and Edward O. Wilson have described the territorial nest protective behaviour thus "... *Oecophylla smaragdina* maintains direct nests near the borders, in which aging workers stand guard. These individuals [which] are no longer as capable as younger workers in the care of young, nest repair ... position themselves to be the first to meet enemies that breach the colonies' territorial boundary. Near the end of their useful lives they assume the greatest risk on behalf of the colony. It can be said that while human societies send their young men to war, weaver ant societies send their old ladies."

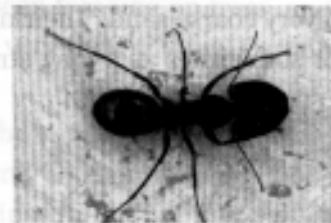
Leptogenys processionalis

These are black ants that can be seen moving about in long continuous lines; they are large in size, and sting powerfully when disturbed. These ants are quite large when compared with other members of the ant kingdom. The long processions are undertaken for foraging. When nests have to be relocated, they can be seen tumbling, in large numbers, out of their underground nests from a hole, and then organising themselves in orderly straight lines towards their new destination. These procession ants with a single node are seen in areas with a lot of vegetation. Fierce hunters, they are known to raid termite nests.

***Camponotus* species**

Camponotus has a single node and is a common ant in India. We describe below two species of ants of this genus that we have observed at Rishi Valley.

(i) *Camponotus sericeus*: These ants are black in colour but with greying green lines on their abdomen. They do not sting. We observed that they were not always only ground dwellers; they were frequently seen climbing trees, poles and water pipes, foraging back and forth, and were very active. These ants milk aphids and can be seen frequently on crotons that are usually attacked by aphids and mealybugs.



Camponotus sp.

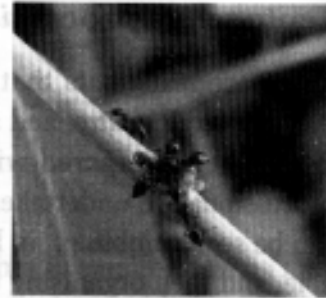
(ii) *Camponotus* sp

These are harmless, blackish ants slenderly built, and can be seen moving in lines like the procession ants. But unlike the *Leptogenous* which is a big ant with huge mandibles, this is a gentle ant, lightly built and does not sting when

its line is disturbed. They, too, nest underground and occasionally we have noticed them in association with termites that harvest fungal spores. During the months of July and August these appear on the ground, specially on the soil, as several dirty brownish-yellow patches that is a close network of fungal mycelia; soon there are small white toadstool like fungus appearing, and these ants are seen amongst the fungal mycelia. What is of interest is the fact that those fungi are cultivated by termites and often appear as spots close to termite mounds.

***Crematogaster* sp.**

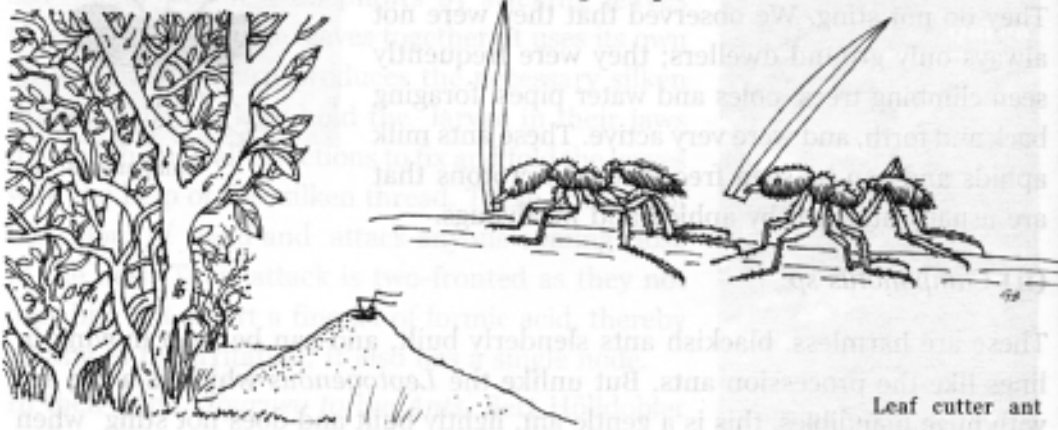
All the ants that will now be described have two nodes. *Crematogaster* are 'tree ants' which build papery nests on trees. Their thorax is red in colour and the abdomen (gaster) is black and triangular, almost heart-shaped. A typical behaviour of these ants is that they raise their gaster up when they sense intrusion. When the ants vacate their nests in trees, then the rufus wood-peckers occupy it for nesting purposes.



Crematogaster sp.

Solenopsis geminata

These are small sand-coloured ants, a smaller version of *Oecophylla*, but can be distinguished by their smaller size or their two nodes. They make their nests under the soil. They inflict a painful bite, which gives rise to a burning sensation; hence the name 'fire ants'. They can be seen almost throughout the year, but become prominent during May to June. They are seen in areas where the soil is a very coarse sand. Their nests are seen as little mounds of soil along the ground, or sometimes as a long stretch of sand heaped up.



Leaf cutter ant

Monomorium sp.

Certain species of this genus, along with the genus *Pheiodle*, are referred to as 'harvester ants'. At Rishi Valley we observed these ants that are black in colour in the months of October and November. They were seen carrying long blades of grass and leaves of herbs into their underground nest. It was a fascinating sight to see them move — like soldiers in a march past holding raised flags and rifles.

Pheiodle sp.

The nest shown here is that of the *Pheiodle sp.*, also referred to as harvester ants. The colony had small black ants actively carrying seeds into the nest. These nests are noticed in areas generally uninhabited. The nest architecture is completely different inside from what is observed outside when the nest is complete. A complete nest has an appearance of a large pot strengthened by concentric walls. Several such nests were seen scattered in the open spaces of the Sahyadri hills. It would be interesting to know whether these fort-like structures are connected to one another by subterranean tunnels or whether they are all individual nests.



Nest of *Pheiodle sp.*

Tetraponera rufonigra

These ants can be recognized by their colouration and size (See plate 17). These are large ants whose head, gaster and second node are black in colour, and the rest of the body brown. Quite aggressive, they can be seen foraging on tress, and nesting in the hollows of dead branches. They deliver a very painful sting. Certain spiders mimic them.

Camponotus, *Prenolepis* and *Oecophylla* belong to the subfamily Formicinae; *Leptogenys* to subfamily Ponerinae. These ants have only a single-noded petiole. *Tetraponera* belongs to the subfamily Pseudomyrmicinae, while the rest of the ants described here, belong to the subfamily Myrmicinae; these ants possess two-noded petioles. Ants are a fascinating group of insects whose colonies are being referred to as a 'Super-organism'. They can make roads, form bridges across water, weave silk threads, cultivate crops, rob other ant colonies, engage in wars and capture slaves. In fact, a horrifying sight in the insect world is to see a live cockroach, moth or grasshopper being captured by the procession ants and cut into pieces in such a way that within a few hours, nothing remains of the insect.

ORDER HEMIPTERA

Entomologists have further sub-divided this order into Heteroptera and Homoptera based on the nature of their forewings.

Sub-Order Heteroptera:

This order comprises 'true bugs'. The term 'bugs' is generally used to describe all kinds of insects, spiders and other small life forms that sting, bite or harm human beings. However the term 'bugs' indicates a very specialised group of insects that are characterised by smells unique to them as well as being only liquid feeders. For understanding this term think of the bed bug, with its characteristic smell and its food: human blood!

The word Hemiptera means 'half-wing'. The forewing of heteropterans called hemielytra is thick and leathery near the base, and membranous near the tip at which point they overlap. The forewings are kept folded flat over the insect's back, thereby protecting the hindwings that are membranous and used for flight. Between the folded wings is a prominent triangular sclerite (a chitinous plate) called the scutellum which is nothing but the modified dorsal part of the third thoracic segment.

An identifying feature of heteropterans is their elongate, piercing-sucking mouthparts which arise from the ventral or anterior part of the head capsule. The mandibles and maxillae are long and thread-like, interlocking with one another to form a flexible feeding tube called proboscis. The labium is beak shaped, which is a protective sheath enclosing needle like stylets that shorten or retract during feeding.

The Heteroptera has a diverse assemblage of insects that have become adapted to a broad range of habitats — terrestrial, aquatic and semi-aquatic. Predominantly phytophagous there are some that show both omnivory and carnivory.

Smell is a form of defence. The disagreeable odour is secreted from stink glands that are located at the back of the abdomen in the nymphs and in the undersides or sides of the thorax in the adult. This disagreeability is advertised through bright colours and bold patterns.

True bugs undergo partial metamorphosis with the eggs hatching into nymphs that resemble the adults of their species. These nymphs moult about five times before they complete their growth.

As in other insect orders, we have dealt with only the most commonly seen ones at Rishi Valley. It might be interesting to know that there are 23,000 species of true bugs around the world.



Chrysocoris sp.

FAMILY Scutelleridae: Shield-back bugs

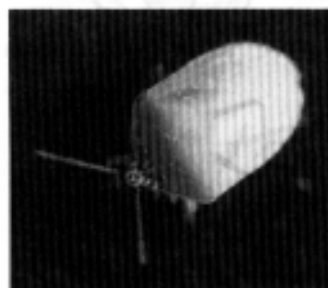
These are usually hard-bodied bugs whose scutellum cover their entire abdomens. They are bright, metallic-green, blue or copper-coloured bugs often mistaken for beetles from which they are readily separated by the rostrum. The commonest of the species is *Chrysocoris sp.*, a very commonly seen bug; bright metallic green on the upper side, orangish underneath, with black dots that mark the openings of spiracles. These are seen in large numbers clinging to the plant *Croton bonplandianum*. This bug is very destructive for plants as it sucks the sap out of them. Some of these bugs are also bright, metallic-blue.

FAMILY Pentatomidae : Stink-bugs

These are commonly called 'stink-bugs'; it's not difficult to imagine why they are called so; in self-defence they will emit copious quantities of liquid that stink to repel their enemy. They have a prominent scutellum. Some of the Pentatomid bugs are also referred to by some as 'shield bugs'. Their common food plants are *Gynandropsis* and members of the Cruciferae family.



Stink-bug



Shield bug

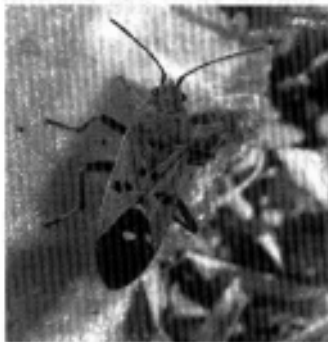
Acanthostomids are bugs similar to pentatomid bugs. They are small to medium sized insects whose head is keeled laterally. Antennae are five-segmented and tarsi are two-segmented. They are phytophagous and mostly associated with trees and shrubs. They are commonly called 'shield bugs'.

FAMILY Coreidae: Leaf-footed bugs

The Coreid bugs are elongate with curiously-shaped, leaf-like expansions on their legs and, therefore, many of them are also called 'leaf-footed bugs'. The scutellum is small and the rostrum (beak) is not curved. These bugs can be generally seen on pulses and fruit-bearing trees like lemon, etc.



Leaf-footed bug



Seed bug

FAMILY Lygaeidae: Seed bugs

These are a large family of plant bugs that look like coreid bugs and can be differentiated by the lack of leaf-footedness and the antennae insertion being on the side of the head. Presence of ocelli differentiates them from Pyrrhocorids. *Lygaeus* is the commonly seen species on *Calotropis*. Another one which breeds on the milkweeds is predaceous on mealy bugs.

FAMILY Reduviidae: Assassin bugs

The strong curved beak is characteristic of this family; assassin bugs belong to this family. They are large, often hairy, dark coloured, blood-sucking predatory bugs with a characteristic elongate head and sometimes are wingless. *Harpactor sp.* is a commonly seen reduviid bug. It is a red-coloured bug quite active during the daytime amongst grass and herbs. It is predaceous on *Dysdercus sp.*

FAMILY Pyrrhocoridae

These bugs are typically bright red and can often be mistaken for Lygaeid.

Absence of ocelli distinguishes them from lygaeids. *Dysdercus cingulatus* is the well known red 'cotton stainer bug' of India. They can be seen in large numbers in the late summer months. Their scutellum is black in colour, and many of them have white bands on the ventral side of abdomen.



Cotton stainer bug

FAMILY Cimicidae: Bedbugs

Flat, tough, wingless, reddish-brown external parasites that predate on humans by sucking their blood. Nocturnal, they remain concealed in cracks and crevices in the furniture during daytime. It takes only about 8 weeks for the eggs to hatch into nymphs and mature into adults. It is capable of injecting into the wound it makes a drop of saliva to prevent the blood from clotting, and it is this saliva that causes irritation. They have a very hard, sclerotised body, and cannot easily be destroyed. They have no natural predators.

Aquatic bugs**FAMILY Belostomatidae: Giant water bugs**

The largest bug known is the *Belostoma sp.* They are brown, oval and flat in shape, the largest species nearly 2 inches long. Their front legs are modified to capture the prey, while the hindlegs are flattened. Don't try to pick them up for they can inflict a painful bite. They are commonly found in ponds, feeding on a variety of insects and small vertebrates. The females lay their eggs on the back of the males who take care of them until the eggs hatch. During rains you can see them come towards the light.



Water bug



Aquatic bugs

FAMILY Notonectidae: Back swimmer

These are so named because of their behaviour — they swim upside down. They can be mistaken for water boatmen but can be recognised by their swimming habit. They are small insects whose dorsal body surface is convex. The hindlegs are flattened and serve as paddles. The forelegs are modified for grasping prey. These insects, too, inflict a painful bite.

FAMILY Gerridae: Water striders

Commonly known as the 'water-skaters' or 'water striders', these are flattened and velvety-haired bugs that cannot be missed in a pond. They have fully exploited the phenomenon of the surface tension. They can literally walk on the surface of water without their hindlegs breaking the water surface. They feed upon the insects that constantly fall into the water body where they live. This family includes the only true marine insect; three species of the genus *Halobates* have been reportedly seen in the Indian ocean.

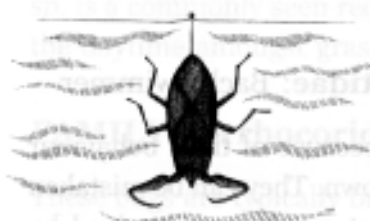


Water strider

The ripples created by insect prey struggling to escape from the water acts as a signal for the water-skaters to capture them with their front legs while still darting across the water on their other two pairs of legs. *Gerris nitida* is a common species found in wells and ponds.

FAMILY Nepidae: Water-scorpions

Commonly called the 'water-scorpion' because of the presence of a conspicuous fore-leg with claws and a long, slender, breathing-tube at the tip of the abdomen resembling the tail of a scorpion. Flat, brown, leathery bugs with very short antennae, they can be seen at the edge of water bodies, close to the banks, moving under the water with their tails just sticking out above the surface of water. The tube is kept open to the air by water-proof hairs arranged like a circle around the tip which spreads out on the surface. They are poor swimmers. They suck the blood of small aquatic vertebrates which are their prey. *Nepa sp.* is the commonest genus of this family which is about 20 to 43 mm in length.



Water scorpion

Sub-Order: Homoptera

The characteristics of these insects have been sufficiently studied now to be awarded the status of a separate order. Homoptera means 'similar wings' emphasising the fact that the wings on these insects are uniformly membranous unlike the unique wing design of the Heteropterans. The wings of homopterans slope in a roof-like manner over the body. There are subtle differences in the mouth parts too, while these also have a piercing, sucking variety, their beak-like projection is placed towards the posterior end of their head, projecting down. In food habits too, they differ from heteropterans in being exclusive plant feeders. There are about 45,000 species of homopterans worldwide but we confine ourselves here to species commonly found everywhere.

FAMILY Cicadidae: Cicadas



Platycleura octoguttata



cicada nymph

Cicadas, so famous for the shrill calls of its males (their calls can be heard upto a mile or more) are a characteristic presence in jungles, woodlands, forests etc. The sound-producing structures are membranous areas of cuticle called tymbals present on the sides of the first abdominal segment. Grizmek compares the sound produced by tymbals to the click-like sound made by depressing and releasing the arched lid of a metal box. A cicada produces 120 to 600 rasping noises per second by oscillating its tymbals. It has been reported that the frequency of repetition determines the pitch of the call, and further modulation is made by raising and lowering its abdomen. Below the tymbals is an air-sac that contributes the amplification of the sound. The cicada develops from the egg to the adult in a rather leisurely fashion, taking anywhere between a few to even 17 years. Although the eggs are laid on the bark of trees, the nymphs that hatch drop off to the ground, digging deep into the soil and sucking sap from roots as they embark on their growing years.

FAMILY Cercopidae: Froghoppers

Froghoppers are also called 'spittle bugs'. These names refers to their larval and adult stages respectively. They are called spittle bugs because of the frothy white mass produced by the nymphs as a nest. The adults are 4 to 5 mm in length, have a frog-like appearance, and their habit of jumping from one spot to another for locomotion earns them the name froghoppers. Spittle bugs can be seen as bubbly white spit upon grasses and herbaceous plants on which the nymphs usually feed. (By carefully separating the frothy mass, you will be able to see the greyish-green wingless nymphs). The froth is merely the excess sap exuded from the anus to which the nymph whips up a mass of air such that the sap becomes frothy.



Froghopper

FAMILY Aphididae: Aphids

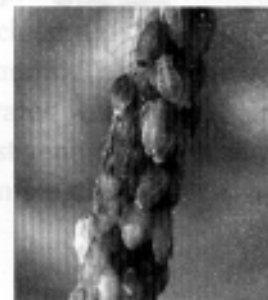
Aphids or 'plant lice' are a very interesting group amongst the homopterans with an interesting life cycle. They are minute, soft-bodied, polymorphic and mostly wingless. Very few of them exist with wings. Sometimes females far outnumber the males. Aphids cause different kinds of diseases on plants. *Aphis neri* are the aphids seen on the milkweed plant and are yellow in colour. They can be seen in practically all kinds of plants.



Aphids

FAMILY Coccidae: Scale insects

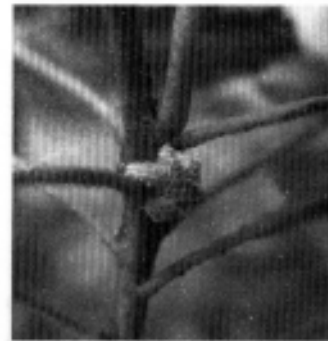
A group of sedentary, soft-bodied bugs with peculiar body organization; scale insects belong to this family. They are generally seen in clusters as a white or creamy fluffy mass. These are the females which usually have discoidal fleshy bodies without any body segmentation or wings.



Scale insects

FAMILY Pseudococcidae: Mealy bugs

Mealy bugs are sexually 'dimorphic', meaning that the sexes have distinct morphological differences. Females retain their nymph-like characteristics, exhibit reduced morphology, and are wingless, though unlike many female scale insects, they often retain legs and can move. Males are winged and do change completely during their lives. Mealybugs do not undergo complete metamorphosis. But male mealybugs do exhibit a radical change during their life cycle, changing from wingless, ovoid nymphs to flying adults. Mealybug females feed on plant sap, normally from roots or other plant parts. They attach themselves to a plant and secrete a powdery layer (therefore the name mealybug) used for protection while they suck the plant juices. The males on the other hand are short-lived and do not feed at all as adults; they only live to fertilize the females.



Mealy bug



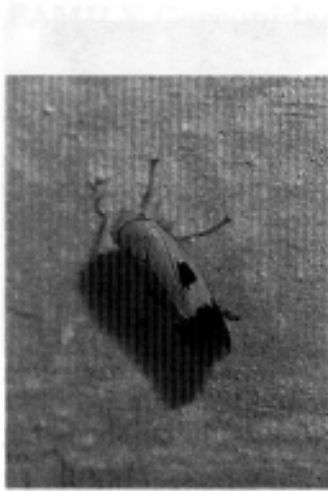
Cow bug

FAMILY Membracidae: Tree hoppers

These are cowbugs, some of which are very bizarre-looking insects. In almost all of these insects, the pronotum assumes curious-looking shapes that project forward over the head or backward over the abdomen. They can be shaped like horns, spines, knobs, etc. The cowbug in the accompanying image has a pronotum pointing in a manner so as to make the insect appear as a thorn or a part of the plant on which it feeds. They are small, jumping insects about 3 to 10 mm in length, but capable of jumping nearly a metre in one single leap. About 15 species are known.

FAMILY Delphacidae : Planthoppers

Terrestrial insects that jump as well as fly. They are tiny, terrestrial, stout-bodied, sap suckers, seen on plants and often attracted to light. They have a three-segmented tarsi; wings are kept sloping roof-like over the abdomen. The prominent spur on the tibia of the hindleg separates this group from other hopper-types.



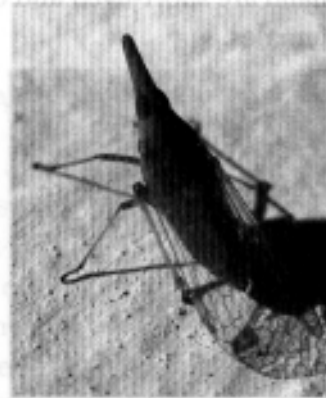
Leafhopper

FAMILY Cicadellidae or Jassidae: Leafhoppers

These are smaller and more active than cicadas. Unlike the froghoppers there are one or more rows of spines present in the hind tibia. Seen from above they are also more elongate than froghoppers, three-segmented tarsi and the absence of a 'Y'-shaped vein in the anal area of the front wing are two of the features used for identification. With piercing, sucking mouth parts they feed on plant sap; many are pests that transmit pathogens like viruses. Leafhoppers too are songsters, but their sound is too feeble to be heard by humans. The tymbals or sound-producing organs are located at the base of their abdomen.

FAMILY Fulgoridae : Lantern flies

The Family Fulgoridae contains some colourful planthoppers called lantern flies. This name was based on an erroneous report that some species produce light when they mate. Many fulgoroids are recognised by the conspicuous snout which is an extension seen on the front of the head. These can be hollow elongate process, or long, narrow and upturned and, in some cases, quite colourful too. They serve no purpose other than to ward off predators.



Fulgorid

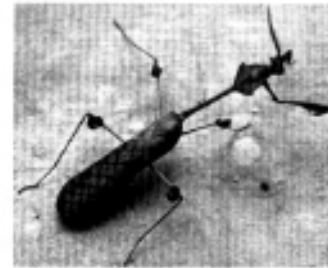
ORDER MANTODEA

The insects that belong to this order are commonly called as mantids or mantis. The genus name '*Mantis*' was given by Linnaeus; it is Greek for 'soothsayer' or 'prophet'. In Africa, mantis species seem to have an important role in nature as representations of gods and spirits. The most commonly observed example is the preying mantis.

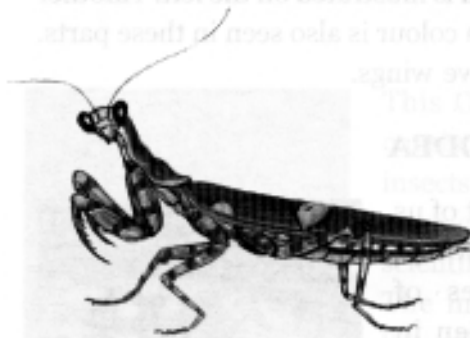
One of the most interesting species of mantids is the *Gongylus gongyloides*. The male is quite different in colour from the female, as also the nymph. These

are most curious-looking preying mantids that have developed very special features for camouflage.

The common preying mantis is green in colour with its powerful toothed and spined forelegs held in a position which seems to imply praying. Like all mantids these, too, are excellent hunters, hence the name preying mantis. They are found amongst vegetation where they are very well camouflaged and can hunt easily. They are predominantly visual animals with a movable head on which are protruding eyes, a slim neck-like prothorax and highly specialized fore-legs. They stalk their prey and wait patiently to accost it. The Great Indian Mantis (*Hierodula membranacea*) has a pair of light green transparent veined wings that resemble leaves. Eggs are deposited in two or more rows in an ootheca (egg case) which is fixed to a branch. Very often these oothecae are parasitised by wasps. The nymph of a preying mantis is brown in colour and often mistaken to be stick insects.



Violin mantis



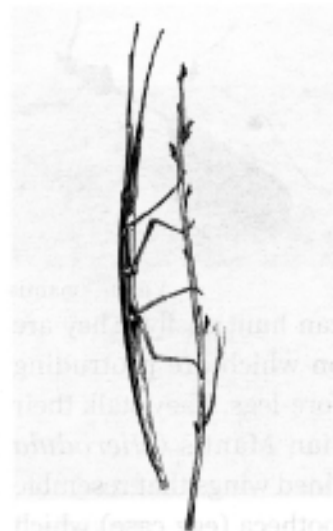
Preying mantis

Yet another specie of preying mantis seen is half the size of the one described above with peculiar markings on its wings. It is green in colour with circled markings of red and green. Other mantids found in the

Valley are 1 to 2 inches long, brown or brownish-pink in colour, and they give a very sharp nip when touched. All mantids protect themselves by nipping with their serrated forelegs. Mantids serve to keep a check on insects injurious to plants.

ORDER PHASMATODEA

The scientific name 'Phasmida' refers to the weird appearance of the members of this Order which consist of stick and leaf insects. This word is derived from a root word in Greek which means 'apparition'. Although they are referred to as stick insects, these are masters of mimicry and very nearly invisible in their natural habitats. Their body structure strongly resembles twigs and dried

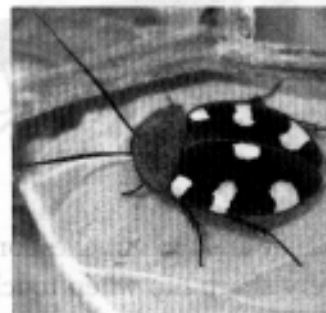


Stick insect

branches on which they are normally found. This sort of imitation of plant parts is called phytomimesis. Phasmids should not be called grasshoppers since they cannot jump. Their movement is very slow in what can be described as an 'insect stroll' and often move only at night. They also sway, mimicking a plant branch swaying in the wind. They are very long, perhaps the longest in the insect world. The female of the stick insect at Rishi Valley reaches a length of nearly 4 inches. Surprisingly the male is a 'midget' hardly an inch long. Their reproductive cycle is also of interest. The common phasmid one seen at Rishi Valley is the *Carausius sp.* which is illustrated on the left. Another stick insect green in colour is also seen in these parts. The leaf insects have wings.

ORDER BLATODEA

This order consists of cockroaches. While most of us are familiar with them, it is of interest to know that worldwide there are over 3500 species of cockroaches. Cockroaches are not only seen in houses but are also found in gardens amongst fallen leaves and in forests. Although they are considered filthy and vectors of diseases, they keep themselves scrupulously clean and neat. The giant cockroaches of the West Indies region are capable of producing sound by flapping their upper part of the foreleg on wood. It is believed that when several of them make the sound at the same time, the noise is loud enough to wake up a sleeping man!



Cockroach

ORDER DERMAPTERA

The name of this Order means 'skin winged' and has reference to the large fragile hindwings. Elongate and slightly flattened, this order includes the earwigs. They get this name due to a misleading belief that the insects creep into human

ears and pinch the eardrum with their pincers. The most conspicuous feature of the earwig is the pair of toothed forceps-like structure at the end of their abdomen. They are darkly-pigmented insects. The forewings are short and truncated, thereby exposing much of the abdomen. The hindwings are membranous and kept closed beneath the forewing while at rest. Antennae are long and multi-segmented. They are nocturnal and spend the daytime under leaf debris. Most of them are predators of other soft insects. The forceps-like cerci are more stout and straight in females, but slender and curved in males.



Male and female earwigs

ORDER THYSANURA



Silver fish

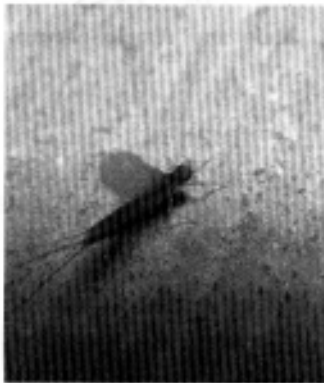
This Order along with the Order Archaeognatha consists of a group of insects referred to as 'primitive' insects. The word 'primitive' implies that they have evolved from ancestors who were wingless. In scientific parlance these are referred to as Apterygota. The most familiar example of this group is the Silverfish. It is predominantly a tropical insect but is found worldwide; about 360 species have been identified so far.

They are omnivorous scavengers, found on litter, feeding on starchy materials like books, paper, pictures, files, etc. These shiny, silvery-white or grey-coloured insects are shaped like that of a fish and bear near the tails a long filament; a paired cerci can be seen at the posterior end of their abdomen.

They are mostly nocturnal and can be found free-living on litter, under barks of trees, underground in caves in the burrows of certain mammals or in association with ant or termite nests.

ORDER EPHEMEROPTERA

This Order includes mayflies — fragile insects measuring an average of 3 cm in length; adults have a very short life-span; they are the shortest-lived insects (hence the name ephemeroptera) whose bodies are small, soft, delicate, greenish-brown in colour but with very long tails or caudal appendages, which are generally three, sometimes two. They have two pairs of delicate, membranous wings that have several parallel veins interconnected by cross-veins and therefore the whole wing appears like a net. They have unusually large eyes which also



Mayfly

can be a mark of identification. It is generally said that the adults emerge in the month of May and hence the name mayfly but in Rishi Valley we have seen their emergence soon after the south-west monsoon. In one night there were hundreds of mayflies resting on the walls of one of the residential houses. It would not be an exaggeration to say that the wall appeared plastered with them. They get attracted to light; hence in a restless manner they were seen flying into the air in groups and then coming back to the wall. We wondered why they

chose that spot. The water source close to the house did not seem adequate to lay their eggs unless they were laying them in the very moist soils of the potted plants and garden around. The light was definitely attracting them.

During such single emergence they do not feed; they merely mate, lay eggs and die before sunrise. Not all of them died, for many were to be seen the following morning on the wall. There were also several other insects ready to prey upon these mayflies. Although the adult mayfly lives for a few hours to a day, their larval life may extend to a year or two and in an aquatic medium feed on diatoms in water. The question is: What edge, in terms of survival, is bestowed on the species through this disproportionate length of larval life?

ORDER NEUROPTERA

This Order meaning 'nerve wings', is a reference to the many, branched veins in their wings which are all equal in size and shape; the wings are held roof-like over the abdomen when at rest. This order includes ant-lions and lacewings.

Lacewings:

A greenish, shimmering insect with sparkling eyes and transparent wings, it looks so fragile that it deserves to be called the lacewing. The most remarkable aspect of lacewings are the stalked eggs (see page 6) it lays on the pods and leaves of trees — several white, glistening eggs held at the end of long slender stalks. The green or common lace wing can be commonly seen, and some green lace wings leave an unpleasant smell when they are touched. These can be seen at twilight. They feed on small insect larvae, specially aphids, thus acting as an effective pest-controlling agent.



Lacewing

Ant-lions:

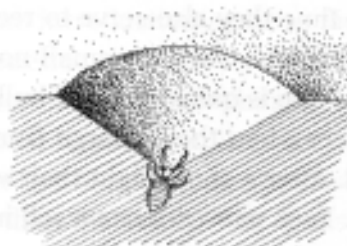
Ant-lions are medium-sized, black-coloured insects often mistaken for dragon flies. They can be distinguished from the dragon flies by the presence of their long antennae and by the absence of black spots on the wings. The ant-lion actually refers to the larvae which specialise in feeding on ants. These larvae make small conical pits in the loose sand where ants generally are found. They wait concealed inside the sand at the bottom of these pits. When an unwary ant slips and slides down the loose sandy cone and falls into the pit, they are siezed at once and sucked dry. These larvae have long, sickle-shaped mandibles and strong legs which aid in capturing and sucking the prey. Ant-lions can be reared, and their development into adults can be observed in laboratory conditions. These antlion larvae pupate into silken cocoons under the sand before they emerge as adults.



Adult



Larva



Antlion pit

ORDER TRICHOPTERA

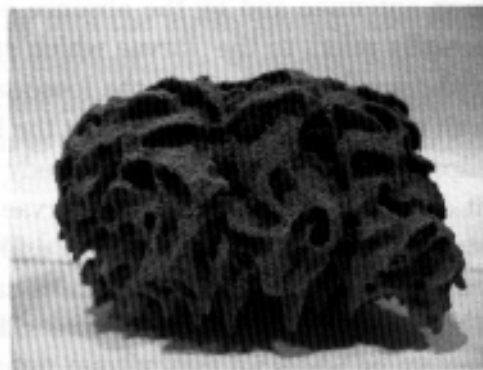


Caddisfly larva in case,
adult and larva

Caddis Fly are moth-like insects with hairy wings and vestigial mouth parts. The larvae are the caddis worms. These larvae live inside cases which they make using silken threads and small sticks, grains, small pebbles or sometimes even tiny molluscan shells or any other material available in the fresh-water environment that it breed in. The head and the thorax can be seen outside the case, and at the slightest disturbance these are withdrawn into the case.

ORDER ISOPTERA

This order includes the grand architects of the insect world, the termites which are commonly referred to as 'white ants'. The term isopteran describes the wings which are equal in size. These are social insects with clearly differentiated caste systems. They are cellulose feeders and dead wood and plant materials are their favourite food. This is both good and bad for the humans, for they can cause serious damages to buildings; at the

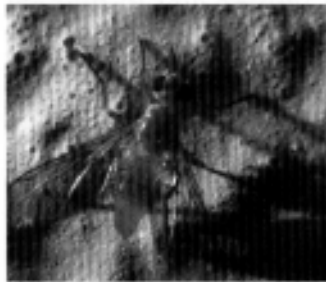


Fungus garden of termites

same time they also serve to recycle dead plant materials. Termites have biting mouth parts. They are small not growing beyond 10-12 mm in size except the queen who is quite long and bulky. Look out for these insects soon after the first showers when they emerge from their tunnels and chambers for their annual ritual. After a short flight their wings break off and the males and females form pairs. Each pair excavate a cell in soil or wood and mate. These are the king and queen which rear the first brood. In many village communities in India the termite queen, is a sought after food considered both delicious and nutritious.

ORDER DIPTERA

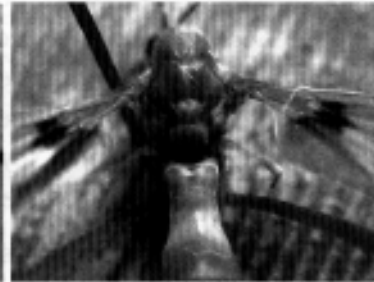
Flies, mosquitoes, and gnats constitute this group. They are called Diptera because they possess only one pair of wings (forewings); the hindwings, are reduced to small structures called halteres or balancers. Antennae are mostly short and compound eyes are large and conspicuous. Although they possess only two wings, they are among the best fliers of the animal world. As adults, all dipterans are liquid feeders. Among the blood-sucking flies, gnats and mosquitoes, it is only the female that sucks blood. The males do not bite, and obtain their nutrients from plants. Dipterans undergo complete metamorphosis.



Fly-profile



Fly's head



Halteres

Examples of selected families we have been able to observe and identify are described. Family Muscidae (house-fly) and Family Culicidae (mosquito) have not been included.

FAMILY Tephritidae: Fruit flies

These are commonly called fruit flies, small with beautifully banded wings. They are destructive to mango, orange, guava, pumpkin and other fruits. Some of the larvae of these flies are leaf miners and live inside the leaves. They can be seen as patterns of dry tunnels on the leaves.

FAMILY Drosophilidae: Banana flies

These banana flies (also called fruit flies) need no introduction as these flies are a famous tool for classical experiments in genetics, extensively used in the laboratory. This is because *Drosophila* completes its life cycle within 5-6 days, and the ease with which they can be reared even in empty milk bottles made them favourites of geneticists. These are not the eye flies that are seen with the approach of the mango harvesting season and then the South West monsoon—irritating as one attempts to read. They are small, chubby flies with large red eyes. Leave an overripe banana and you will find them with ease.

FAMILY Calliphoridae: Blow flies

Slightly bigger than the house flies these are commonly called the blow flies or the 'blue-bottles', because of their bright, metallic blue and green colours. They lay eggs on dung or carrion, sometimes even on the open wounds of animals. *Lucilia* and *Calliphora* are two common genera seen in India.



Blow fly

FAMILY Syrphidae: Hoverflies

These are also known as 'flower flies' as they are seen hovering over or resting on flowers and feeding on nectar. Thus they also resemble bees in not only behaviour but also in their body markings, but can be differentiated by the typical head of a fly with big eyes. Their flight is interesting to watch—dart, hover, rest, etc. Their larvae feed on aphids.



Hover fly

FAMILY Tabanidae: Horse flies

Robust flies, whose bodies are broad and flat; big eyes that are iridescent or with brightly-coloured spots or stripes. No bristles on the body. Males can be seen on flowers but the females bite and suck the blood of cattle, horses, other animals and even man. Males feed only on nectar and pollen.



Tabanus sp.

FAMILY Bombylidae: Bee flies

A family with a number of species from the plains of India, especially drier places. A characteristic feature of the fly is its stout, hairy, furry body. Scales are present sometimes. Head is rounded, eyes are contiguous in the male; proboscis is long and can be seen protruding out.

FAMILY Sarcophagidae: Flesh flies

These grey and black flies are common all over India. They have a grey thorax, with longitudinal black stripes, a black and grey checkered abdomen and large red eyes. Bristles noticeable in the abdomen. Since they lay their eggs in rotting meat, carrion or dung, they get the name 'flesh flies'.



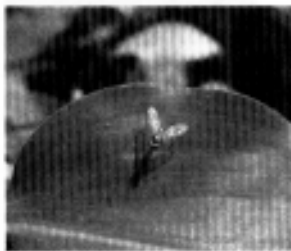
Flesh fly

FAMILY Asilidae: Robber flies

Robber flies are larger than most flies, have a long body with strong bristles and are abundant especially in the plains. They do not fly much but wait for their prey by staying close to the ground on twigs or leaves and then take off quickly when they spot their prey. The males with big claspers can be distinguished from females who have pointed ovipositors.



Mating robber flies



Long-legged fly

FAMILY Dolichopodidae: Long-legged flies

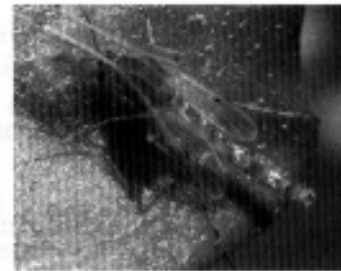
Small, slim flies that are generally metallic green or blue and, as the name says, with long thin legs. They are seen in moist places and soon after rains. They are predatory flies feeding on small insects and, thus, are of economic importance. Antennae two jointed, proboscis short and fleshy.

FAMILY Tipulidae : Crane-flies

Slender bodied, long-legged, large, thin flies with a characteristic V-shaped groove on the thorax, adult flies are common in areas that are moist and have a lot of vegetation. The tip of the abdomen of the male is rounded, whereas in the females it is long, pointed and tapering. The larvae usually feed on decaying vegetation.

FAMILY Chironomidae : Midges

These at first glance, look like mosquitoes. But the way they hold their body and legs will help in identification. Males have plumose antenna. The wings do not cover the entire abdomen. At rest, the insect keeps its fore legs raised and in front of its head. They can be seen in swarms and generally do not bite or cause any harm to humans. Eggs are laid in beautiful spirals enclosed by a jelly capsule, stuck to stones or weeds. Ocelli absent; proboscis short. The photo here is a chironomid, green in colour, effectively blending with the surroundings.



Green midge

ORDER ORTHOPTERA (Straight-winged insects)

The name orthoptera is derived from the Greek 'ortho' meaning straight and 'ptera' meaning wing, and refers to the parallel-sided structure of the front wings (tegmina). This order includes grasshoppers, crickets and locusts. Almost all of them are good jumpers; this feat is achieved with the third pair of limbs which have been modified into jumping legs. They are also the 'musicians' of the insect



Grouse locust

world. Sound is very important for courtship in orthopterans. Therefore they have very well-developed tympanic organs, sensitive structures located either on the tibia of each front leg or on each side of the first abdominal segment. They produce sound either by rubbing their spiny hind femurs (thighs) against a projecting vein of the forewing or rubbing a part of one forewing against a file-like vein on the other, like drawing a bow over a violin string. These songs or stridulations are generally produced by the males and each song is unique.

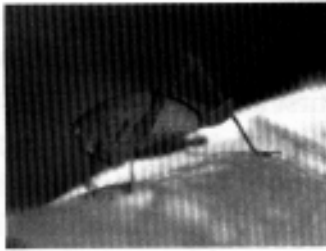
All orthopterans fall under two broad suborders, each of which is then classified into several families. The two major suborders are:

1. Ensifera which have elongate and bendy antennae with many segments and is represented by katydids and crickets. Katydid is an American term and these creatures are referred to as longhorned grasshoppers; while the english term 'bush crickets' is more apt as in their features they are more closely related to crickets than to grasshoppers. These are the musicians of the orthopteran order.
2. Caelifera, with short, straight antennae is represented by grasshoppers and locusts.

We give below descriptions of certain select orthopteran families:

FAMILY Tettigoniidae: Katydids

These have long, slender antennae which are longer than their bodies. Large insects, usually greenish, most of the forewing slopes over the side of their body and a small part of it remains horizontal and dorsal. The curved or sword-shaped



Nymph of katydid

ovipositor of varying sizes serves to identify the female (see plate 27). The pronotum (chitinous plate covering the thoracic segment) is like a collar with the wings tucked underneath them. The auditory organ is on the tibia of the foreleg. The males produce the sound by rubbing the wings together. They get the name from the sound they make which is like

'katydid, katydid'. Look at the colour plates for the different types of katydids. The genus *Conocephalus* sp. looks almost like the coneheaded grasshopper, but for its long antenna and brown colour. *Sathrophyllia* sp. is brown and coloured like the bark of the tree on which it can be found. *Mecopoda* sp. mimic the leaves of a plant, the tegmina, with marking similar to the leafveins. Their wings and the colour serve to camouflage them well in the bushes and trees where they are found.

FAMILY Gryllotalpidae: Mole-cricket

The forelegs of this insect are modified to form a powerful, digging tool, to make burrows in the soil. Their lives are spent in their subterranean burrows which they make in moist sand or mud. Into these burrows the female will deposit her



Mole cricket

eggs. These brown insects grow to an inch in length. The forewings are wrapped around the soft abdomen and the hindwings extend backwards and appear as slender processes beneath the tegmen. This is a characteristic of most crickets.

FAMILY Gryllidae: House-cricket

Gryllus is the common house cricket that hides in the kitchen and pantry feeding on left-overs. The species which seen in gardens and under stones is completely black in colour. They advertise their presence in the evening through their high-pitched calls.

Crickets: Nocturnal insects that remain concealed under stones and burrows during daytime. They have shorter forewings and somewhat flattened bodies. They are equipped with feeler-like cerci on the tip of their abdomen. Their sound is more musical and of a higher pitch than that produced by the bush crickets.

FAMILY Acrididae: Short-horned grasshoppers and locusts

Herbivores, common in grasslands and can be found almost everywhere. Antennae short, the auditory organ can be seen on the first abdominal segment; the ovipositor composed of short parts and used also for digging. Hindlegs long and saltatorial (this order used to be called Saltatoria). The colour is so harmonious with nature that sometimes it is not easy to spot them. This order is well-documented as they are one of the most injurious creatures to agriculture. We describe a few here:

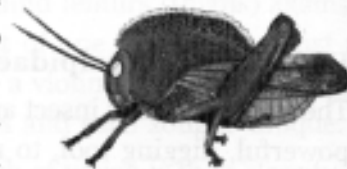
Poecilocera picta is the painted grasshopper you can see on the calotropis. Its colouration is a kind of warning to its predators of the bad taste they are likely to get, and so birds avoid it.

Teratodus sp. is commonly called the 'hooded grasshopper' and can be seen in places where there are bamboos. The pronotum is produced as a sharp hood over the body giving it a striking appearance. It is brightly coloured and looks extremely beautiful in flight. They have an overall appearance of green leaves.

Atractomorpha is one of the coneheaded grasshoppers that is quite a pest. The female is green in colour and the male is brown. It is quite different from *Acrida sp.* or *Concephalus sp.* (shown in plates 26&27 respectively), and is slender in size.



Immature painted grasshopper



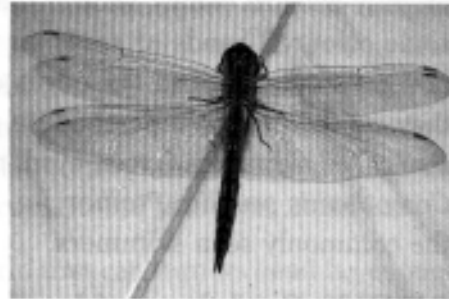
Hooded grasshopper

ORDER ODONATA

The word 'odonata' means 'toothed ones'. This order consists of dragonflies and damselflies. Their funny antennae, so small in comparison to their body size and which look like small needles, distinguish them. This feature will help to distinguish them from adult owlflies and ant-lions also whose bodies and wing patterns at first glance appear to be similar to dragonflies. The bristle-like antennae, two pairs of equal-sized, elongate, membranous wings, large, compound eyes taking up most of a space in the very mobile head help to identify them. Odonata consists of three groups:

Anisoptera (which includes dragonflies), Zygoptera (which includes damselflies), and Anisozygoptera (a near extinct group represented by only two living species, one of them seen in the Himalayas).

Dragonflies are the most accomplished fliers of the animal kingdom, capable of flying high, at nearly 35 miles/hour; they can reverse direction in midair, hover, fly backwards, catch their prey in mid air and mate as they fly. Their adaptation for flight gives a physicist cause for ecstasy and to replicate it is an aeronautical engineer's dream. Unlike other insects which have developed mechanisms to hook their wings together, the odonatans' wings act independently, in a physicist's language operating in 'antiphase'. Their powerful compound eyes having more than 10,000 units as well as their strong thorax muscles have contributed to their strong flying ability. The dragonflies are also excellent bio-controllers of pests, such as midges, mosquitoes, the larvae of flies, etc.



Skimmer

The dragonflies and damselflies shown in the colour plates were taken at Suchindrum, forests near Gudalur, at the Tiwai Hills near Pune and at Rishi Valley. You can see them easily near ponds, pools, etc., and soon after the rains. Look out for them in large numbers near rice fields during harvest seasons. Interestingly, the nymphs of odonata are completely aquatic, carnivorous and different to look at. The metamorphosis is incomplete. You can collect the exuviae (moult) of *naids* as they moult to become an adult.

ANISOPTERA

Under this group come the dragonflies called Darners, Clubtails, the Biddies and the skimmers. Their hindwings are broader than the forewings at the base. Three most common families are described for you.

FAMILY Aeshnidae:

Commonly called darners, because of their flight resembling the darning needle, these are large dragonflies in beautiful colours. Their compound eyes meet along the top of the head. Wings are generally clear. Can be seen far away from water sources hunting in the air for insects

FAMILY Gomphidae:

Commonly called clubtails for their swollen terminal abdominal segments. Do not fly as much as other dragon flies, preferring to rest on leaves, twigs or stones and catching their prey when moving from one resting place to another. Eyes are wide apart and legs generally spread out.

FAMILY Libellulidae:

Most commonly seen dragonflies and usually called 'skimmers'. They have brightly-coloured bodies, shorter than their wingspan. Most of these speices have some coloured bands or spots on their wings. They fly swiftly and sometimes hover also. Seen along the edges of ponds, lakes, streams and even marshes, they can be observed perched on plants. There are other dragonflies that are also called skimmers (green-eyed, river skimmers) that belong to other families. *Crocothemis seivillia*, *Ptomarcha*, *Neurothemis* and *Brachythemis* species are the commonly seen skimmers.

FAMILY Cordulegastridae:

Commonly called 'biddies', they can be identified by their compound eyes that meet only at a point along the head and are separated otherwise.

ZYGOPTERA

Wings equal or hindwings small in some. Wings held vertically above the body when at rest. Damselflies belong to this group and are divided into two families. Calopterygidae with broad wings, and Caenagrionidae with narrow wings (This is a very oversimplified classification for beginners). The narrow-winged damselflies are more commonly seen. Their wings are clear and narrow or stalked at the base, and the sexes vary in colour, the males being more bright. The broad-winged ones have wings that are dark or have brightly coloured spots. Their wings are not stalked. The females will have the ovipositor at the end of the abdomen which are absent in the males. The colour plates show two narrow-winged damselflies. A male of the commonly called 'Bluets' or *Pseudagrion sp.* and a female of *Ceriagrion coramandelianum*.



'Bluet' damselfly



6. The Marvels Of Insects

The insect world is so full of unique features that it is too vast to be captured within the space of a small book such as ours. Hence we have attempted to describe different ways in which insects have been perceived or studied in each of our chapters. In this chapter we give you some examples of some features seen in the lives of insects that would seem, because of the way we look at life's processes, not normal. The descriptions in this chapter are taken not just from various reference sources we read in the course of our work, but also from our observations of insects at Rishi Valley. We have called them 'marvels' because as we studied insects, they never ceased to capture our attention. Read on.

A **mantis** is one of the few insects in the world that can turn its head far enough to look over its shoulders. A mantis seldom moves fast. A male mantis exhibits the same slow speed even when is stalking a potential mate. Once within range, it must leap upon the female's back and land symmetrically. If it fails to do so, the female will be able to reach some part of him with her grasping legs or jaws and devour him bit by bit. Amazingly, the male's nervous system shows such functional subdivision that it can mate with the female even while she is destroying his head and beginning to consume the forward parts of his body. Gradually he becomes nourishment for the young that will develop from her eggs. A male that aligns itself exactly on the female can escape this deadly fate to father more offspring.

Cecidomyian gall midges are tiny flies which can grow and develop by two different pathways.

In some situations they hatch from an egg, go through the normal sequence of larva and pupal moults, and emerge as ordinary sexually-reproducing flies.

In other situations females reproduce by parthenogenesis. Here is how it happens:

Parthenogenetic females stop development at an early stage and never become normal adult flies, but reproduce while they are still larvae or pupae. As larvae

they develop live within their mother's body; not supplied with nutrients or a protected uterus, they develop right within the mother's tissues, eventually filling her entire body. In order to grow these larvae eat their mother from inside. A few day's later they emerge, leaving a chitinous shell as the only remains of their only parent. And within two days their own developing children are beginning to literally eat them up.

These females do not lay eggs.

Parthenogenetic reproduction will continue as long as food is abundant.

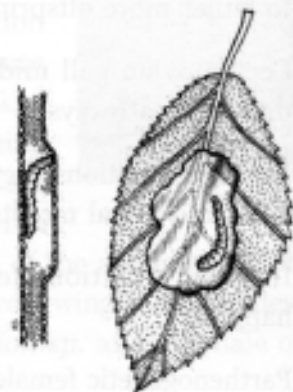
When food diminishes all-male and mixed broods of male and female develop. If female larvae are not fed at all, they grow into normal flies.



Weevil

Weevils that are half the size of a human thumb, live on the vegetation of the mountainous rain forests of Papua New Guinea. These sluggish, long-lived insects, their backs covered with algae, lichens, and mosses look like miniature travelling gardens/forests. In this microhabitat dwell distinctive species of tiny mites and nematodes. It seems that enterprising insect species find and invent new habitats/niches when conventional ones niches have already been filled or are too competitive to exist. Remarkable adaptation indeed!

Leaf miners: The caterpillars of this species are so very small that they can hollow out a path inside a leaf without injuring the tissues of the leaf. Since they eat only the tender interior tissues, that is, the tissues that contain the chlorophyll, their mines show up as light lines on a green background which indicates that only the colourless epidermis remains in the leaf. The little larvae manage to combine the business of feeding with the construction of a tube-like dwelling, the roof and the floor of which consists of the tough and unchanged layers of the surface tissues of the leaf.



Leaf-miner

Bagworm or case worms (Psychidae)

These are small, dark-colored moths with an adult life span of two or three days. Females are wingless and remain sitting, most of the time, on the spot where they emerge from pupation. In that same spot they attract males (by scent) and lay their eggs. Upon hatching, the tiny caterpillars spin little silken tubes. These are then attached to plant or soil particles from which they never leave again. Like caddis worms they can carry their little homes about with them. Found on tree trunks, these are difficult to spot because they cover their 'bags' with materials from their immediate surroundings which makes them virtually invisible. Look out for these on the trees near the senior school assembly hall at Rishi Valley. According to available literature, sometimes the eggs develop through parthenogenesis too.



Cases of moths and caddis flies

In 2001 a team of scientists led by Professor Jacob Ishay from Tel Aviv University, Israel, reported their discovery that oriental hornets attach a tiny magnetic crystal to the roof of each hexagonal chamber in their nest. The crystals are glued with saliva to the centre of the roof of each cell away from the egg. These crystals, it seems, serve the hornet like a 'surveyor's spirit levels' ensuring that nests are aligned correctly as new cells are added and the nest increases in size. The team believe that the crystals help the worker caste to assess the symmetry and balance of the cells by comparing the magnetic field with the gravitational field. Hornets' nests are built with horizontal layers of combs supported by vertical scaffolds. These magnetic granules made up of largely titanium were seen only in those cells intended for workers (which build the nest). The ones housing the queen had crystals with silicon, aluminium, calcium and iron but very little titanium. It is possible that the crystals also help the hornets to navigate in the dark chambers. The tiny opaque round crystals, with a diameter of 0.1 mm approximately, belong to a family of materials called perovskites. Their composition appears similar to the natural magnetic mineral ilmenite FeTiO_3 . A study is to be undertaken of whether bees and wasps use the same magnetic technique.



Paper wasp

Paper Wasps

Rishi Valley is a rich storehouse of paper wasps and hornets. (These descriptions below arise from our own observations from what we have read, and from what we have learnt from Dr. Gadgkar's team at IISc). The foundation of the nest is accomplished by a single female, fertilized the previous year, which

has survived the winter by hibernating in a sheltered spot. She is the queen of the colony. At first this queen wasp has to work entirely unaided, like the potter wasp. Without help she builds a home, lays eggs, collects food and tends her first brood for her future helpers to emerge. The eventual size of the nest is made possible through the lightness of the building material. This unique substance is a kind of paper made of small particles of wood, shaved off by the wasp with her mandibles from wooden beams, posts, boards etc. to which saliva is added to give it cohesion. Man has learned the art of making paper from wood fibers and a binding material by observing the wasp.

The choice of a nesting place of a queen paper wasp that we had observed has baffled us. She built a nest right under the table where regular biology classes were held. Another was built under the shelf where we stored glassware for regular use in the lab. Fascinating, also was the fact that our presence never deterred the wasp from scraping off paper from our files to build her nest or fly in with materials from outside. Neither did she sting any of the students, reserving that act for Gangulu, our lab assistant. Having decided the place for her nest, she used some of the rapidly-hardening paper pulp to make a kind of stem, from which she suspended a very small comb. Wax combs of honeybees are vertical and carry cells on both sides; the combs of wasps are horizontal and have cells only on the underside.

*Ropalidia marginata*

The nest is soon extended into a multistoried building as these builders add storey after storey from top downward, suspending each new comb from the one above by column like supports. They also extend the combs laterally. As the interior structure expands, the outer walls are enlarged. Constant alterations are made, parts that are too close to the centre are pulled down and new ones added,

providing for more space, in this way very large nests develop in a single summer. A single egg hung from the walls develops into hungry larvae that keep popping out everytime the workers come in. Each cell is covered by materials spun by them as pupation starts.

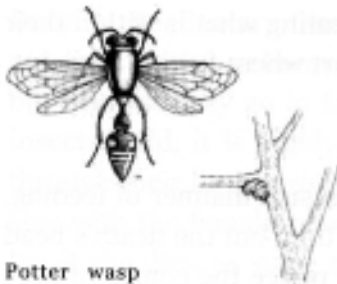
Honey bees

In contrast to the paper combs of wasps which normally are horizontal with cells only on their undersides, the combs of bees are made of wax, they hang vertically, and have cells on both sides separated by a wall in the middle. They serve for the rearing of the brood, and for the storage of honey and pollen. It requires exceptional skill from worker bees and drones to vary the size of the hexagonally shaped cells, to manufacture such extraordinary thin walls, and then to orient them accurately in space.



Bee

Potter wasps Architects of clay, fashioning delicate little pots of clay, attaching them to a plant or to furniture, inside bamboo hollows, singly or in groups camouflaging them, Potter wasps are amazing to watch and learn from. The female potter wasp collects her material from a patch of clay soil; if it is too dry, she moistens it by spitting on it water she has fetched and stored away in her stomach. She then scoops up small amounts of clay and forms them into little pellets with the help of her mandibles and front legs. The saber-shaped legs make excellent tools for the job. Holding the pellets between head and thorax, she carries them to her building site. Using legs and mandibles she applies them to the site, and then turns them into flat narrow strips that is slowly and neatly spread. Adding strip to strip she builds up a small hollow sphere with a narrow neck or a pitcher which is beautiful to look at with the opening at the top and



Potter wasp

which has a neck like that of a bottle. The nest is combination of masonry and artistry, and the female potter wasp is at once the builder and the potter. These nesting chambers apparently served American Indians as models for the shape of their clay jars. After building the nest, the wasp goes hunting and collects a number of beetle larvae,

spiders or caterpillars, paralyzes them, and presses and squeezes them in through the hole from the outside. Having stocked the nest, she inserts the tip of her abdomen into the opening, lays an egg, and secretes a liquid which quietly hardens into a thread. On this thread then hangs the egg in between the paralyzed larvae at the bottom, so that the wasp grub can start feeding immediately on hatching. As soon as the egg is laid, the wasp closes the opening with a final pellet of clay and takes no further interest in the nest. Some species like the *Sceliphron* species take care to add mud on top of the nest to camouflage it making it look like some untidy patch of mud.

Moths

Our book would be incomplete if we did not mention the colourful moths. Moths are considered dull and/or wicked since many of them do cause harm. Not much has been written about their beauty or some marvelous features in comparison with the literature available on their close cousins, the butterflies.

Read on about some facts that fascinated us...



Gondontis sp.
(Geometrid moth)

Clothes moth

We know them as destructive moths. But they evolved in a manner that was meant to be constructive. With their instinct to lay eggs in the fur or plumage of dead animals, these moths perform a useful role as scavengers in nature. As humans evolved and began to wear garments, moths too, seem to have broadened their resource sources to include clothes that are made out of natural materials. The eggs deposited on our garments hatch into small caterpillars after a week and embark on their work of destruction. Resting away in comfortable silken tubes which they spin from materials like wool or hair, the larvae only need to put out their heads to feed. When they finish eating what is within their reach, they extend their tube to reach out to another part where food is available.

Death's head hawk moth

The marks on its head gives it this name. It has an unusual manner of feeding. The proboscis of most other hawk moths are long and thin, but the death's head has a short but massive one. With this the moth can pierce the combs of bees

and suck the honey; one nocturnal visit to a beehive can get it as much as a teaspoonful of honey. To prevent the bees from rushing to attack it, it makes chirping noises by sucking air into its head. These noises have the same effect as certain tones produced by the bees themselves for mutual inhibition of aggressiveness. At times when it is unable to find its way back from out of the nest, it meets with death at the hands of the bees, unable to escape their sting. Beekeepers sometimes find the moth's body embalmed in wax.



Death's -head hawkmoth

Coleoptera :

They are fascinating insects, which are still being discovered. Look at these facts!

- 300,000 known species in 4 suborders; 1/3rd of all described animal species, 2/5th of all insects; cosmopolitan, almost everywhere except the seas.
- all shapes and colours; in sizes from less than 0.25mm to 20cm.
(For beetle maniacs, there is information on other pages too. We confine this chapter to something that is a marvel.)

Burying beetle:

Burying Beetles are the undertakers of the natural world. They spend their time tracking down and burying the dead bodies of small animals, mostly birds and mammals. However they do not do this out of any misplaced sense of tidiness. Their real aim is to use the bodies they bury as food on which to raise their young.

Burying Beetles are fascinating not only because they are large attractively coloured beetles, or because of their gruesome interest in small vertebrate corpses, but because they go in for a great deal of parental care of their young. In the insect world, it is highly unusual for adults to stay and protect their eggs all through their larval growth until the larvae are ready to pupate. For the male to stay with the female, sharing the work load with her, and even standing in for her if she dies, as some male Burying Beetles do, is truly amazing.

Burying beetles locate carcasses by smell. The last segments of their antennae are enlarged and flattened to increase the surface area, which enhances their ability to detect the odours of decay. If a male locates a carcass that does not already have a female on it, it waits for sometime for one to arrive. If no female arrives, he adopts a special posture on top of the carcass and emits a pheromone which attracts females. Some males will cheat by adopting this posture without having found a carcass and though they generally succeed in getting a female to mate with



Burying beetle

them they generally do not end up fathering because the female will mate again and the last male to mate with her normally is the father of most of her brood.

While preparing the carcass for burial, they remove the hairs and/or feathers and shape the carcass into a ball as much as they can. A lot of effort goes into looking after the carcass, keeping it clean and free from bacteria and fungi by spreading their hindgut, antibiotic secretions over it, which delays the processes of decay. The carcass is kept in its own special burial chamber beneath the leaf litter or soil, sometimes as much as 60 cm below the surface. The American species *Nicrophorus americanus* is an endangered, one and there is a captive breeding programme to save it.

Chrysomelids

There is a Chrysomelid Beetle, *Diamphidia simplex* in Africa which exudes a poison which is a powerful haemolytic and causes death by general paralysis; it is used by the Bushmen of Africa to 'tip' their arrows.

FACT FILE

Some of the questions young children often asked us when we spoke of insects, were queries such as 'Which is the fastest insect?', 'Which is the most beautiful?' etc., etc. For those with a penchance for knowing these facts, here are a some facts which have been adapted from the University of Florida Book of Insect Records.

Fastest Flier

This fact is established after airspeeds have been measured with sensitive equipments. The insects are desert locusts (*Schistocerca gregaria*) and corn earworm moths (*Helicoverpa zea*). These fly at average airspeeds of 33 and 28 km/h respectively (about 21 and 17 mph). Scientists believe that insect airspeeds are the least known aspect of insect flight.

Most Spectacular Mating

The widely cultivated bees, *Apis mellifera* have the most spectacular mating because there is a posse of drones pursuing the females. The winner forfeits a portion of his phallus at the end of mating. The drone dies soon after this.

Fastest Wing Beat

This was decided by using a beat-frequency oscillator as well as personal auditory analysis. Sotavalta (1953) found that a midge of the genus *Forcipomyia* belonging to the order Diptera, and family Ceratopogonidae could generate a wing beat frequency of 1046 Hz.

Longest Diapause Among Insects

Diapause is the condition when, during metamorphosis, the pupa stay in a suspended state of growth and not hatch according to the normal cycle. Its like hibernation. This is often a technique used by insects to overcome unfavourable conditions and has contributed to their success. The yucca moth *Prodoxus riley* of the order Lepidoptera, family Prodoxidae has the longest reported diapause observed under artificial conditions.

Smallest Eggs

The smallest insect eggs are the microtype eggs of *Tachinidae*, which are usually 0.02 to 0.2 mm long. The eggs of *Zenillia pullata* are exceptionally minute, only 0.027 by 0.02 mm.

Most Toxic Insect Venom

Based on experiments carried out with mice, it has been found that harvester ants in the genus *Pogonomyrmex* have the most toxic venom. How these otherwise non-predatory creatures developed such a deadly venom is an

interesting discussion. It is believed that they must have developed this in order to escape capture by predators and hence its toxicity to vertebrates.

There is more, but our intention was only to whet your appetites so that you would seek more and maybe study them in a scientific manner and add to the existing body of knowledge.



PART THREE



The butterfly counts not months but moments, and has time enough.

— Rabindranath Tagore
Stray Birds



7. Entomology As A Pastime

For too long now the insects have been shunned as vermins, pests and God's curse for man's evildoings. They are none of those. They live their lives just as we do, for the very same purposes, looking for food, increasing their numbers and ensuring that their lot do not go extinct. In the process, no doubt, they inflict some harm on us; however, let's not forget that we are also dependent on their services at sometime or the other. So forget any preconceived notion about them, and view them as they are.



Braconid wasp

For a nature lover the study of insects can be as fascinating as studying birds or flowers or mammals. The beauty of entomology lies in the fact that you can find insects anywhere and everywhere, anytime and everytime. Depending on your level of interest, you can spend anywhere between a few minutes to a few hours to a whole or more days matching and studying insects, and we can promise you that there will not be a moment of boredom. For a beginner or a budding entomologist, watching insects can be quite fulfilling.

Very simple tools are necessary to study insects. These can be obtained from shops or with a little trouble can be designed and made by you.

Observing insects:

Insects are never still. You can watch their behaviour freely as they go about their jobs; but when you want to have a closer look at them without harming them or yourself, we suggest that you carry some basic equipment. A wide-mouthed, clear glass or plastic jar (like an empty jam bottle or a pickle bottle) is

useful in confining the specimen for you to have a closer look. You can make small insect boxes or buy them from shops (like hobby stores that keep pet food etc., or museum shops). An insect box is a small box with a magnifying lens fitted on the lid.

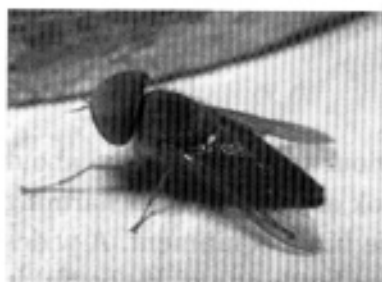
A good quality glass hand lens, available from companies that supply biological items is a useful tool. A magnification of 8x to 10x is quite sufficient. Small lenses that can be carried in your pockets are available and they are not expensive. This serves to reveal details of the insect like, for e.g., the shape of the antennae, or the mouthparts, etc.

These tools help you to gather some basic details about the insects; however if you wish to identify an insect to the level of species, as professional entomologists do, then you will need more equipment and in some cases you would require a microscope if you wish to identify ants, flies, wasps etc.

Handling Insects:

Sometimes insects fascinate you so much that you may want to pick them up and keep them with you for a certain extended period of time. It is good to remember that many insects sting and bite, and, therefore, it is not advisable to pick up an insect unless you are familiar with the insect's behaviour. If you still do, then you must take adequate care

and also ensure that the insect is placed in an environment that will cause it minimum stress. You will need a good pair of gloves—surgical gloves or plastic gloves would do. If you cannot find a glove then remember to cover your hand



Tabanus sp.



Fly

with a plastic bag before picking up the insect. If you are a person with a misplaced sense of courage and want to pick up a wasp, then you will need very thick gloves. (We advise you not to pick up wasps till you become sufficiently familiar with handling insects and even then great care needs to be exercised. This is because humans have various levels of tolerance for the

venom injected by some wasps. Our lab attender Gangulu's palm began to swell after he was stung for the third time by a paper wasp that was allowed to build its nest in our biology lab).

Insect nets are useful. Readymade insect nets are available. There are aerial nets, sweep nets and dip nets that are used by entomologists as per their need. You can have a general-purpose net made by using an old badminton racket. Remove all the guts from the racket; look for an old mosquito net/mesh cloth (the preferable option is the mosquito net). Stitch the net around the frame of the racquet, such that the net forms a cone within the racquet (see figure). The length of the cloth should be at least two meters long to get a good net. Bigger nets can also be had. You can thread a string around the mouth to close the frame. By pulling the thread, the mouth of the net can be closed, thus preventing the insect that is caught from escaping. This long net is useful to trap butterflies, moths, and other flying insects so that you can have a closer look at it. We have also used large tea stainers



Different kinds of nets

for fishing out insects from water.

Nets used by aquarists as well as nets of the type mentioned above, but made by using nylon meshes instead of cotton ones, can be used to collect aquatic insects and study them. Aquarium nets are good to collect surface-and slow-moving insects, but longer ones will be needed to bring out bottom-dwelling aquatic ones.

Other Equipments Needed:

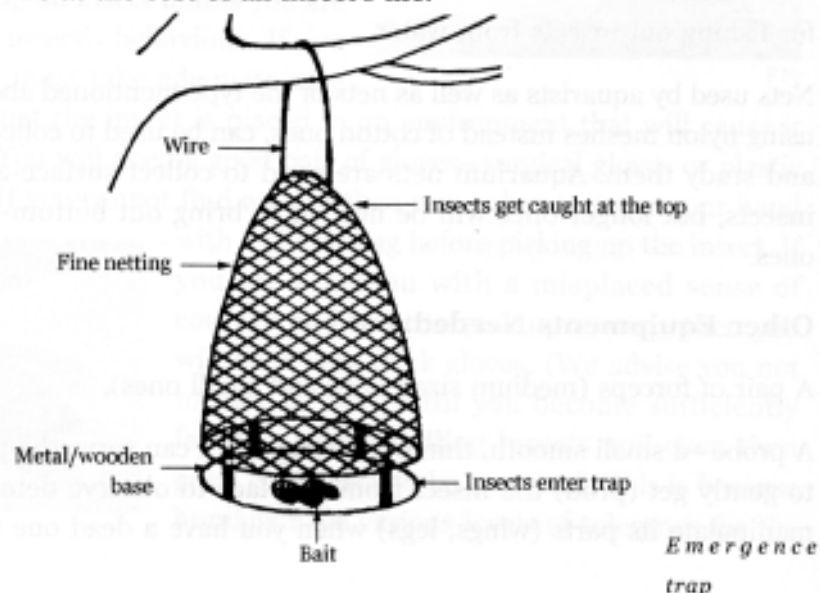
A pair of forceps (medium sized ones and small ones),

A probe—a small smooth, thin but strong stick can serve the purpose, which is to gently get (prod) the insect from its place to observe details, or to turn or manipulate its parts (wings, legs) when you have a dead one with you.

General Items In A Bag For A Field Entomology Study:

- A camel hair brush (no.1)
- A note book (small one)
- A pencil, eraser, pen, sharpener
- A small plastic bottle
- An empty envelope (used old envelopes will do)
- An insect field guide if one is available
- A hand lens
- A small ruler or measuring tape.

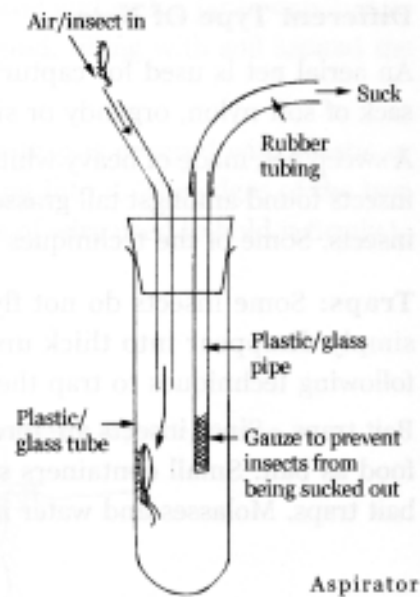
There are many more items professional entomologists' bags will have, depending on the techniques they adopt. That is because they may want to collect insects and preserve them for identification, taxonomical work, research, etc. A brief description of these items and techniques are given below. But for a beginner these are not necessary. We would strongly urge you to study insects without killing them. If they need to be collected, then it must be only because it is absolutely essential. Ensure that their population density is high enough. Unless there is a compelling reason to do so, which taxonomists and entomologists have, insects can be studied without collection or killing. With high-tech digital cameras and camcorders available, collecting details for identification by a layman need not be at the cost of an insect's life.



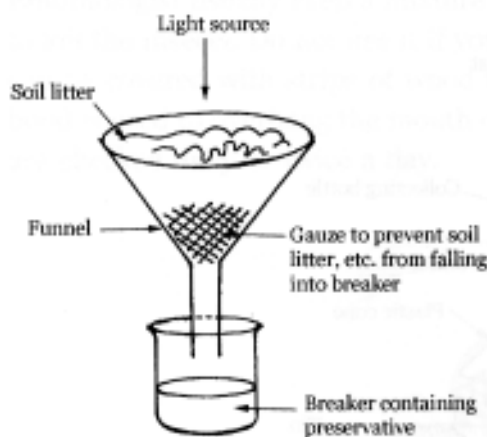
A professional entomologist would have in his/her bag:

An insect killing jar. This is a plastic jar with plaster of paris at the bottom, into which an insect killing poison is added. Although many use potassium cyanide, a less poisonous chemical that can be used is ethyl acetate or acetone (nail polish remover).

An aspirator: Some insects are so small that they cannot be picked up by hand. In such cases an aspirator is used. An aspirator consists of a bottle with a two holed rubber cork. Through both the holes go a small, narrow glass tube one of which is close to the bottom



of the jar but does not touch a surface. The other tube is kept well above the bottom, and is covered by a tiny gauze. This tube is then attached on the outside to a rubber tubing. The entire set up is made air tight. A home-made aspirator can be made by using an old bottle, corks and straws in place of the glass tubes (see figure). The rubber tubing is used to suck the insect into the bottle.



A Tull green funnel for separating small insects from soil

Berlese funnel: This is used by entomologists to collect insects found in the litter of the forest floor. There is a funnel fitted into a glass jar that is lined with moist paper napkins. The funnel is filled with leaf litter. A high wattage bulb is hung over it. As the heat from the bulb warms up and dries the litter, the insects seeking cooler places, move away and fall into the jar.

The items mentioned above are not for a beginner who is going to observe insects in their habitat.

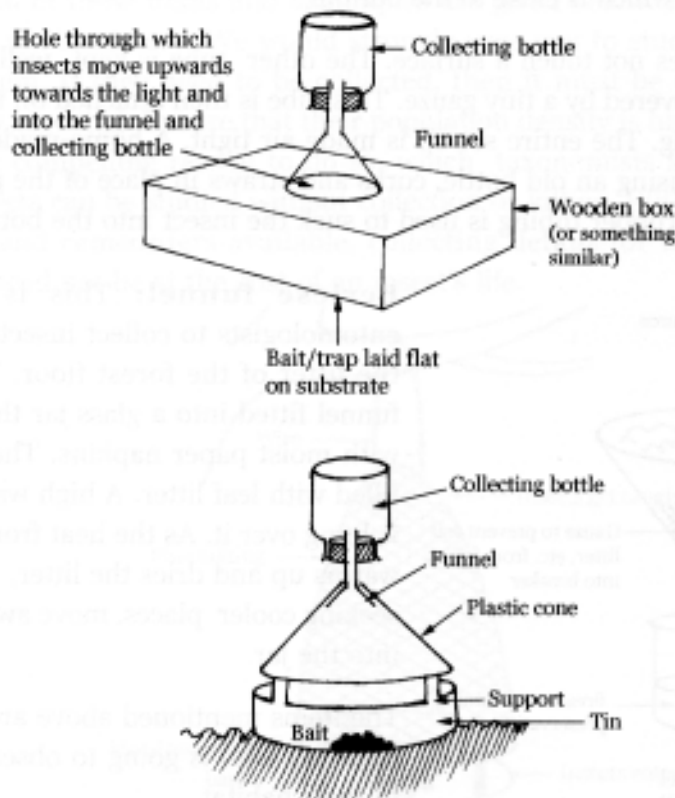
Different Type Of Nets:

An aerial net is used for capturing flying insects out of the air. This is a long sack of soft nylon, organdy or silk netting that will not damage the insects.

A sweep net, made of heavy white muslin or canvas, is used for capturing unseen insects found amongst tall grasses or weeds; a dip net is used to capture aquatic insects. Some of the techniques for scientific study of insects are the following:

Traps: Some insects do not fly or run preferring to stay where they are; or simply disappear into thick underground vegetation. Entomologists use the following techniques to trap them.

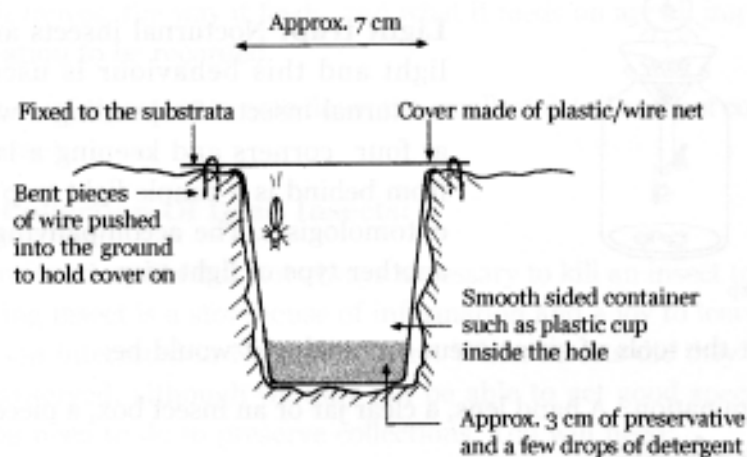
Bait traps - Since insects are forever in search of food, specimens are lured with food as bait. Small containers suspended from trees/branches make excellent bait traps. Molasses and water in equal parts makes a fine bait.



Bait traps

Pitfall traps - Dig a small hole with a garden trowel and sink a jar or cup in it so that the top is flush with the surface of the ground, filling with soil around the outside of the container.

Note, in the figure given that the mouth of the trap is covered with plastic or wire netting to prevent other animals from falling into it. The edges of the trap should be covered with the substrata, and pieces of wire used to hold it firmly to the soil.



A pitfall trap

Entomologist usually keep a mixture of 30% water to 70% alcohol at the bottom to kill the insects. Do not use it if you do not want to kill the insect. The mouth can be covered with strips of wood to keep out rain water. Generally a metal hood is used to overhang the mouth of the trap to keep the rain water out. These are checked daily or twice a day.



Aerial attractant trap



Beating tray



Light trap

Beating tray: A beating tray is made of white cloth stretched over a frame of two crossed sticks. It is held or placed under a tree branch or shrub to which sharp blows are delivered (take care not to damage the plants). Insects will drop from the tree to the tray which can then be gathered by hands. You could use an old umbrella as a substitute for beating tray.

Light trap: Nocturnal insects are attracted to light and this behaviour is used in studying nocturnal insects. Suspending a white sheet tied at four corners and keeping a lantern shining from behind is a simple light trap used by many entomologists. The accompanying image shows another type of light trap.

In short the tools of an amateur entomologist would be:

For examination : A hand lens, a clear jar or an insect box, a piece of cardboard, a probe, a forceps.

For recording: A field notebook, pens and pencils, a ruler or measuring tape, a camera and accessories (optional).

For collecting: A net/nets, aspirator, gloves, forceps, bottles, envelopes, labels.

For identification: A field guide or identification keys.

Miscellaneous: A water bottle, a knife, map of the local area if available, a compass.

Information gathered by amateur naturalists can be of tremendous significance. Discoveries in the world of science have had their beginnings with amateurs and not professionals. Therefore it is also important while observing insects to keep good notes of your observations. A few suggestions for keeping field notes are given below.

Record the date, time, place and climatic conditions (i.e., sunny, cloudy, humid etc.)

Record your observations on the spot and not trust it to your memory. Short notes with a few key words are sufficient. Details can be written up later.

Make a rough sketch of the insect however poor your skills are.

Colour, antennae shape, size, peculiar markings, odour, and shape of the animal are valuable in identification. Wings, eyes, number of abdominal segments, the nature of the last segment, the presence or absence of hair, spines, etc.

Also important is the fact about its habitat. Where the insect is seen, what it was doing, the way it moves, the way it feeds, and what it feeds on are all important pieces of observation to be recorded.

While recording, it is important to note down the smallest detail and not consider any thing irrelevant.

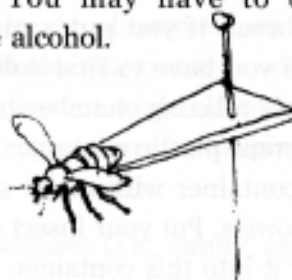
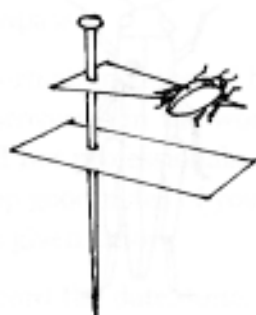
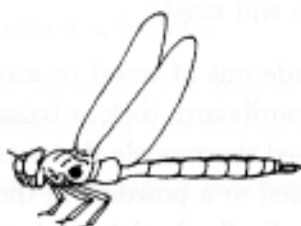
Preserving A Collection Of Dead Insects:

As we have mentioned earlier it is not always necessary to kill an insect to study it. An active, living insect is a storehouse of information and a joy to learn from if you are a person interested in Natural History. When insects die they can be collected and preserved, although we may not be able to get good specimens. Here is what you need to do to preserve collections. You will need:

1. An insect box to store your collection. It can be made out of wood or any other material. The bottom should be lined by a soft cardboard, cork or balsa wood so that the insect pins can go through it. We used thermocole that was going for waste. Keep a few naphthalene balls (crushed to a powder) in the box to ensure that your collection remains intact. Periodically check to replace the naphthalene ball powder.
2. Insects are generally kept pinned in the box. It is not possible to pin dead insects as they will be dry and will break if you put a pin through their bodies. So you have to first soften them. To do that, make a relaxing chamber from a large glass or transparent plastic container that is airtight. Line the container with moist sponge or cotton or paper towels. Put your insect into a small dish and lower it into this container. The insect must not come into direct contact with the wet sponge.



Pinning an insect

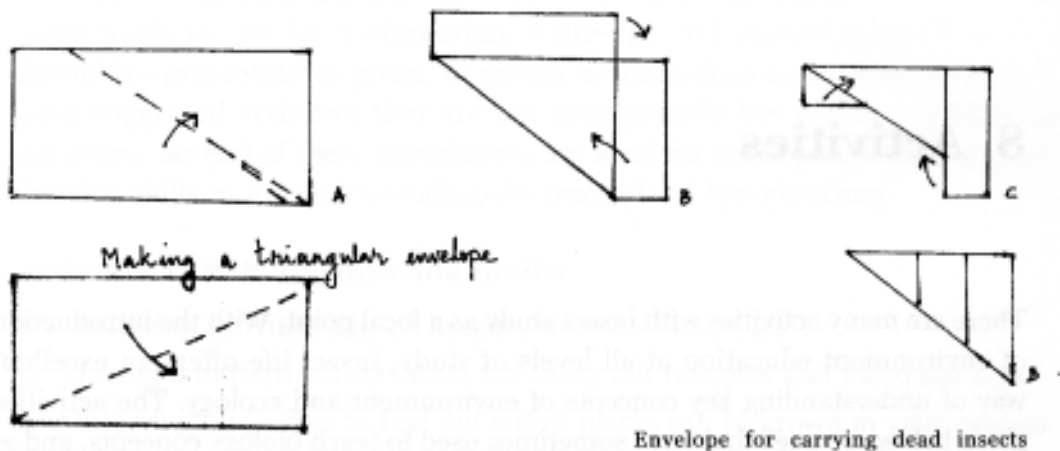


Also keep another separate container with ethyl acetate or else mothballs to prevent fungus growth on your insects.

3. Excepting very small insects, most dead insects can be mounted and kept in the box. There are special long insect pins available either in companies that supply biological materials or even in hobby shops. Bees, butterflies, cockroaches, flies, moths, mantids and wasps should be pinned vertically through the right side of the thorax between the two forewings such that the pin emerging on the underside will not break the insect legs. Beetles and hoppers are generally pinned through the front part of the right wings and the hemipterans are pinned through the right side of the scutellum (see figure). Grasshoppers, dragonflies and damselflies are pinned vertically with one or two of their wings spread out. Small insects are stuck at the end of a small piece of thick cardboard and pinned.

4. Prepare a brief data sheet on a thick piece of paper the date and place where the insect was collected; this is to be pinned along with the insect.
5. Very small insects and soft-bodied insects that cannot be pinned are stored in (70%) alcohol in small vials. Ensure that vials are airtight and seal them well. You may have to occasionally replenish the alcohol.

Ways of pinning different types of insects



6. If you do not have envelopes readily available with you during your field work, then you can make one to carry your dead insect. See the figure above to make one.

We would strongly emphasize that watching insects is an extremely interesting and rewarding pastime. The famous naturalist Henri Fabre, known for his astute and insightful descriptions of insect life, showed what and how much the observing of living creatures can reveal. Collection of insects can be left to trained entomologists whose painstaking and often unacknowledged work continues to make life for humans richer in every realm. Becoming familiar with the habits and behavior of insects is necessary before capturing them. When and if you do capture them, then keep them briefly, take good photographs of them and then release them from where they were collected. Observations and descriptions by amateurs will continue to play an important role in habitat conservation which is essential (as we mentioned in the first chapter) for Biodiversity conversation.



8. Activities

There are many activities with insect study as a focal point. With the introduction of environment education at all levels of study, insect life offers an excellent way of understanding key concepts of environment and ecology. The activities given below are ones that were sometimes used to teach biology concepts, and at other times in our nature club; at the level of the middle school as well as high school. Please refer to the previous chapter for the kind of equipment you would need to carry out these activities.

We would suggest the following steps before attempting the activities:

1. The teacher takes a keen and detailed look at the environment of the student, and the surroundings of the school and its environs.
2. Plan the activity keeping the ability level of the class and the time frame available.
3. To begin with, approach the activity without too many hard and fast rules for students or for that matter high expectations.
4. Make sure that resources for reading and referring to are available.
5. Keep the arrangement as simple and uncomplicated as possible. In other words, do not attempt too many activities at one go or expect too many results at the end of every field study.
6. Prepare clear, unambiguous instructions for students and give it to them in advance, in writing.
7. Most importantly, be clear about the objective of the activity and assess it at the end to find out whether the goal could be reached. Feedback would be useful for the next activity.

Activities can be culminated in many different ways. They could be left open for more work, or call for a discussion; write-ups and posters could be made, assembly—presentations given, or simply a home/class assignment done. We have suggested activities that are not area-specific but can be undertaken anywhere. Several of these experiments are ideal for developing thinking-skills, drawing-skills or for understanding the principle of hypothesizing.

Activities with butterflies and moths

The following activities can be undertaken with butterflies:

1. Making a butterfly-observation net using old racquets and mosquito nets.
2. Observing butterflies to find out which plants can be grown in your campus to keep the population of butterflies.
3. Observing caterpillars to find how much food is eaten per day.
4. Collecting caterpillars to study their metamorphosis into butterflies.
5. Observing the growth of butterflies from eggs to adult.
6. Collecting the wings of dead butterflies (please do not kill live ones for this experiment) and observing them under the microscope to study their scales.
7. Photographing butterflies, caterpillars etc.
8. Observing butterflies and moths to understand their differences.
9. Studying a habitat, using moths and butterflies as key species.
10. Studying mimicry in commonly seen butterflies: Danaid eggfly and the plain tiger; Great eggfly and the common crow; Common mormon with crimson and common rose.
11. Observing and comparing the eating pattern of grasshopper with caterpillars.

Activities with Hymenopterans: ants, wasps, bees

1. Observing ants changing locations to find the reasons for it such as if it has any connection with climatic changes or if it is to find a new source of food.
2. Finding out the ants' response to a variety of food sources and discover the most favoured food source for them.
3. Keeping a colony of ants in the laboratory to study their behaviour. (You will of course need some transparent enclosures for this. Refer to the Bibliography at the end of this book; this will be of help in undertaking this experiment.

4. Studying of different habitats of ants in order to understand their relationship with other species such as termites, plants, etc.
5. Comparing the soldier population of ants & termites (for structure or behaviour).
6. Observing a potter wasp build its nest to raise its young (this could be a long term project too, watching and recording the activities till the larvae hatch)
7. Undertaking a comparative study of different potter wasp nests.
8. Observing a paper wasp build its nest.
9. Studying how a wasp locates its nest.
10. Finding out the common plant sources for a paper wasp nest.
11. Cataloguing the diversity of ants in one's area. (The same can be done for any group of insects)

Caution: Activities with wasps should be carefully undertaken as their sting is dangerous. If confronted by a wasp, hornet or a bee, it is wise to stay still, for these insects do not attack still objects or people.

Activities With Preying Mantis, Stick Insect And Grasshoppers

1. Comparing the body structure of an immature Preying mantis and Stick insect for identification.
2. Comparing the structure of different short-horned grasshoppers.
3. Studying the movement of a Stick insect and a Preying mantis.
4. Studying the movement of a Stick insect under different conditions, such as when it moves normally and when its stalking or capturing prey.
5. Studying the movement of a Preying mantis in the similar way.
6. Studying the features of a Stick insect to identify it.
7. Studying the features of a Preying mantis to identify it.
8. Breeding Grasshoppers to understand incomplete metamorphosis.
9. Breeding Grasshoppers to observe moulting in the nymphs, keeping track of the number of moults, the time intervals, etc., before the adult form is reached.
10. A study of insect eggs for shape, size and the food-plant on which they are laid.

Activities With Beetles :

1. Observing beetles to study the colour and shape to find out whether they served to help in their survival by camouflage or other means.
2. Observing the activities of a dung beetle.
3. Studying beetle larvae and comparing their activity with the adult forms of the species.
4. Studying antennae shapes in beetles.

Activities In General:

1. Studying the larval case of caddis flies, bagworms.
2. Recording sounds made by insects and studying them.
3. Calculating the density of insect population using quadrats or transects.
4. Using the data from the activity to understand the effect of insects on the insects' habitats.
5. Studying the role of insects in the aquatic and terrestrial food webs.
6. Studying the role that insects can play to help replace the use of pesticides.
7. Studying camouflage in the insect world especially in phasmids, orthopterans, hemipterans and hymenopterans (leaf insects, stick insects, grasshoppers, bugs, ants, flies etc.).
8. Studying the different shapes of antennae in the insect world and finding out how they are used and why.
9. Studying the wings of insects and observing their use in flight.
10. Observing the movement of water skaters and other aquatic insects.

The activities listed above would (ideally) require the teacher to prepare the following:

1. A field observation sheet for students.
2. A list of equipments the students would need.
3. An instruction sheet (this could be combined with 1 above although ideally it is good to separate the two).

We have given you an example of each i.e., a field observation sheet and an instruction sheet for a select activity.

Objective: Observe An Insect In Action In An Insectarium

There are a wide variety of insects that can be observed. But to do that continuously in order to gain an understanding of their role in the ecosystem a sustained observation is necessary. In order to do that construct an insectarium.

Insectarium : Before you construct an insectarium you must decide which insect, or groups of insects you wish to observe. Then understand the kind of habitat they live in through observing them in their natural habitat. This will give you an idea of what needs to be made available in the insectarium.

An insectarium can be a terrarium or an aquarium depending on the choice of insect. If you have chosen a terrestrial insect, then construct a suitable house for them. The house can range from a simple wire-mesh cage to a large cardboard box (of the size your TV or oven comes in) to a space in your garden which you fence off with a wire mesh. What is essential is that these places should have adequate space for the insect and space to have plants in them. A potted plant inside a mesh cage would suffice if, for e.g., you are planning to study the habits of a homopteran or hemipteran. You might want to construct a glass case if you are studying ants, where no plants are needed. Use a bit of your imagination along with your observations

The insectarium should be well ventilated, have a door or a cover to keep them secure, and easy to clean; simulate the natural conditions in which the insect lives. Food and water are as important for insects as for us. So provide the insectarium with food plants. Very often insects are able to extract water from their food sources, but if you have observed your insect seeking out water sources then remember to provide a little. A moist sponge left in their cage would suffice. Excess water can lead to growth of fungi. Give some thought to the kind of temperatures in which these insects thrive. If you have constructed the insectarium in your garden around naturally growing plants, then you do not have to worry too much; but if yours is a mesh cage that you are keeping inside, then make sure that adequate warmth is provided (this is particularly important if you live in a place where the temperature drops).

When the insectarium is a large cardboard box, then you must make provisions for light and ventilation. Secure the opening of the cardboard box with a mesh. Similarly provide some small mesh windows for air circulation. Make sure the box does not get overheated.

You might want to keep aquatic insects. In such cases your large aquarium would suffice. Line the bottom of the aquarium with clean gravel and sand. Let them slope adequately so that you can have areas that are shallow and of some depth. Fill the aquarium with water from the source from which you are going to collect the insect and keep it for observation. Do not fill it with tap water. Since some aquatic insects can also fly, keep a wire mesh cover over the aquarium. Keep sticks and plants in the water. The stick standing above the level of water will help insects to perch on them when they want to moult. Do not over-crowd the aquarium. If your water is from a stream, then remember to aerate the water after you fill it in the aquarium. Pond water does not need this to be done.

Use the observation sheet to keep notes of your study.

Random notes on choosing insects to study:

Having built the aquarium/terrarium you may now introduce the insects. It is much better to start with familiar ones. Rearing a butterfly from a caterpillar is the easiest activity, where you can pick up an actively feeding caterpillar and introduce it into the insectarium, provide it with food materials, and watch it grow, moult, pupate and hatch into an adult butterfly. If your caterpillar is that of a moth then sometimes you will find that it takes along time as a pupa. But it would be a fascinating study to observe the differences between the life history of a chosen species of butterfly and a moth.

Bugs that are herbivorous can also be observed in the insectarium. Choose immature ones so that you may observe them feed, grow and moult into adults. Once they are adults release them, for they will need to find a mate to continue the life cycle.

Stick insects can be kept in an insectarium for observations. The common Indian stick insect is a herbivore and feeds of plants. They would be fascinating to watch. If you are able to get a pair to keep, then consider yourself lucky and you may well be contributing to the exiting body of knowledge on stick insects.

Grasshoppers are another group that can be accommodated in yor insectarium and studied.

Dragonfly nymphs live in water and grow into adults that then fly out of the water. These can be collected and studied. Water beetles and bugs are two other

aquatic insects that can go into your aquarium.

Once you have decided on the insect to study and constructed its house, then observe it and keep notes. The observation sheet will help you keep notes systematically. There is one thing that you need to remember. Do not stress the insect as far as possible. And if you are unable to take care of it or provide it with food, release it from captivity.

Record of observation - Chart 1.

Place :

Time :

(This could be maintained week wise. Therefore you could record Week 1, 2,3, and the day/date, etc.)

Observation of :

Cage condition

Feed given:

- Periodicity
- Preferred feeds
- Mode of feeding
- When taking water
- When taking solid food
- Mouth parts

General Behaviour

- Time related (does it behave differently in the morning, evening, etc.)
- Towards food
- Towards humans
- Towards new kinds of insects ones introduced
- Towards its own members
- At rest
- When active

- Objects that interest the insect
- Aggression if any, if so then conditions that cause the same

Growth-related Information:

- Moulting
- Developing new structures, etc.
- Courtship

Record Of Observation - Chart 2

This chart can be used for outdoor work , collecting data for identification or behaviour etc.

- Serial number
- Place found
plants/walls/holes/soil/under stones/water/homes
- Time
Day/dusk/night/bright light
- Activity
- Wings (separately for forewing and hindwing)
No./colour/nature/ position/size/ Venation
- Head position and size
- Antenna shape and size
- Mouth parts
- Thorax
Fused/free/notched/hairy/spiny/smooth etc.
- Legs
Digging/jumping/grasping/swimming/clinging/walking
- Abdomen
Number of segments/spiracles/ovipositor/colouration
- Any other
- Rough sketches

9. Check List of Insects

Given below are the names of insects seen in Rishi Valley.

Lepidoptera: Butterflies

1. *Abisara echerius*
2. *Acraea terpsicore*
3. *Ariadne merione*
4. *Byblia ilithyia*
5. *Caleta caleta*
6. *Castalius rosimon*
7. *Catopsilia pomona*
8. *Cepora nerissa*
9. *Chilades sp*
10. *Chilasa clytia*
11. *Colotis danae*
12. *Danaus chrysippus*
13. *Danaus genutia*
14. *Delias eucharis*
15. *Euchrysops cnejus*
16. *Euploea core*
17. *Eurema sp*
18. *Euthalia aconthea*
19. *Graphium agamemnon*
20. *Graphium sarpedon*
21. *Hasora alexis*
22. *Hypolimnas bolina*
23. *Hypolimnas misippus*
24. *Ixias marianne*
25. *Ixias pyrene*
26. *Jamides sp*
27. *Junonia almanac*
28. *Junonia hierta*
29. *Junonia iphita*
30. *Junonia lemonias*
31. *Junonia orithya*
32. *Leptosia nina*
33. *Melanitis leda*
34. *Melanitis zitenius*
35. *Neptis sp*
36. *Orsotriaena medus*
37. *Pachliopta aristolochiae*
38. *Pachliopta hector*
39. *Papilio crino*
40. *Papilio demoleus*
41. *Papilio polymnestor*
42. *Papilio polytes*
43. *Parantica aglea,*
44. *Pareronia valeria*
45. *Phalanta phalantha*
46. *Spindasis sp*
47. *Syntarucus plinius*
48. *Talicauda nyseus*
49. *Tirumala limniace,*
50. *Vanessa cardui*
51. *Ypthima baldus*
52. *Ypthima sp*
53. *Zizeeria sp*

Lepidoptera: Moths

54. *Acherontia styx*
55. *Actias selene selene*
56. *Agathia sp*
57. *Agathodes ostentalis*
58. *Agrius convolvuli*
59. *Agrotera sp*
60. *Aloa lactinea*
61. *Amata passalis*
62. *Amraica sp*
63. *Anisozyga sp*
64. *Antheraea mylitta*
65. *Antheraea sp*
66. *Argina argus*
67. *Argina astrea*
68. *Asota sp*
69. *Attacus taprobanis*
70. *Brachmia sp.*
71. *Chiasmia sp*
72. *Cleora sp.*
73. *Clostera sp*
74. *Comostola sp*
75. *Cretonotos gangis*
76. *Daphnis nerii*
77. *Diaphania indica*
78. *Erebus macrops*
79. *Eudocima homaena*
80. *Eudocima materna*
81. *Eupterote sp*
82. *Eupterote undata*
83. *Falana sp*
84. *Gesonina sp*
85. *Gonodontis sp*
86. *Grammodes geometrica*
87. *Hamodes sp*
88. *Haritalodes derogate*
89. *Heterostegane sp*
90. *Hippotion sp*
91. *Hyperlopha sp*
92. *Hyposidra talaca*
93. *Lamprosema tampiusalis*
94. *Macroglossum sp*
95. *Maruca vitrata*
96. *Marumba dysas*
97. *Micronia aculeate*
98. *Mocis undata*
99. *Nausinoe sp*
100. *Neoserura litorata*
101. *Nola analis*
102. *Palpita sp*
103. *Parasa sp*
104. *Parotis sp*
105. *Pelagodes sp*
106. *Phalera grotei*
107. *Phazaca sp.*
108. *Problepsis sp*
109. *Psilogramma sp*
110. *Pygospila tyres*
111. *Rhomborista sp*
112. *Sameodes sp*
113. *Sasunaga sp*
114. *Scopula pulchella*
115. *Scopula sp.*
116. *Spirama sp.*
117. *Spoladea recurvalis*
118. *Theretra castanea*
119. *Theretra nessus*
120. *Thyas coronata*

- 121. *Trigonodes hyppasia*
- 122. *Xyleutes persona*
- 123. *Lymantriidae* moth
- 124. *Zyganeide* moth
- 125. *Zeuzera* sp

Coleoptera

- 126. *Anthia sexguttata*
- 127. *Apomecyna* sp
- 128. *Aristobia octofasciculata*
- 129. *Aspidomorpha millaris*
- 130. *Batocera* sp
- 131. *Buprestidae* indet
- 132. *Cassida circumdata*
- 133. *Casinoidea indica*
- 133. *Chlaenius quadricolor*
- 134. *Cicindela* sp
- 135. *Cylindrothorax tenuicollis*
- 136. *Chrysochroa* sp.
- 137. *Epilachna*
- 138. *Dytiscus* sp
- 139. *Gametes versicolor*
- 140. *Helicopraxis tyranna*
- 141. *Henosepilachna vigintiocto punctata*
- 142. *Heterorhina elegans*
- 143. *Holotrichia* sp
- 144. *Lema* sp
- 145. *Macrocheilus niger*
- 146. *Melanotus* sp
- 147. *Menochilus* sp
- 148. *Mylabris pustulata*
- 149. *Myllocerus discolor*

- 150. *Nisotra semicerulea*
- 151. *Nodostoma* sp
- 152. *Odontopus nigricornis*
- 153. *Onitis philemon*
- 154. *Onthophagus* sp
- 155. *Oryctes rhinoceros*
- 156. *Oxycetonia* sp
- 157. *Prionoma attractum*
- 158. *Protetia alboguttata*
- 159. *Psalydolytta rouxi*
- 160. *Pyrochroa*
- 161. *Rhynchophorus* sp
- 162. *Sagra femorata*
- 163. *Stephylinidae* beetle
- 164. *Sternocera* sp
- 165. *Tribolium castaneum*
- 166. *Trictonotoma childreni*
- 167. *Zygogama conjugate*

Hymenoptera:

Ants

- 168. *Camponotus sericeus*
- 169. *Camponotus* sp
- 170. *Crematogaster* sp
- 171. *Dorylus* sp
- 172. *Leptogenys processionalis*
- 173. *Monomorium* sp
- 174. *Oecophylla smaragdina*
- 175. *Pheidole* sp
- 176. *Prenolepis longicornis*
- 177. *Solenopsis* sp
- 178. *Tetraponera rufonigra*

Bees

- 179. *Apis dorsata*
- 179. *Apis florea*
- 180. *Megachlie hera*
- 181. *Nomia sp.*
- 182. *Xylocopa verticalis*

Wasps

- 183. *Braconids*
- 184. *Chelybion benghalensis*
- 185. *Chelybion sp*
- 186. *Cuckoo wasp*
- 187. *Eumenis conica*
- 188. *Evania sp*
- 189. *Fig wasp*
- 190. *Ichneumon*
- 191. *Pepsis sp*
- 192. *Polistes sp*
- 193. *Rhynchium sp*
- 194. *Ropalidia marginata*
- 195. *Ropalidia sp.*
- 196. *Sceliphron madraspatanum*
- 197. *Scoliid wasp*
- 198. *Sphex sp.*
- 199. *Vespa tropica*

Hemiptera

- 200. *Aphis neri*
- 201. *Cantao ocellata*
- 202. *Ceroplastes ceriferus*
- 203. *Chrysocoris grandis*
- 204. *Clovia sp*
- 205. *Coridius ianus*
- 206. *Cyclopelta siccifolia*

- 207. *Cyclopelta siccifolia*
- 208. *Dichoptera hyalinata*
- 209. *Dysdercus cingulatus*
- 210. *Erthesina sp.*
- 211. *Eurybrachys sp*
- 212. *Geocoris sp.*
- 213. *Gerris nitida*
- 214. *Graptostethus servus*
- 215. *Haematorhophus marginatus*
- 216. *Halys sp.*
- 217. *Harpactor sp.*
- 218. *Helopeltis antonii*
- 219. *Icerya purchase*
- 220. *Kalidasa sp.*
- 221. *Leptocorisa oratorius*
- 222. *Leptocoris auger*
- 223. *Lithoceros indicus*
- 224. *Lygaeus miltarius*
- 225. *Menida histrio*
- 226. *Nepa sp.*
- 227. *Oxycarenum hyalipennis*
- 228. *Plautia fimbriata*
- 229. *Pyrilla sp.*
- 230. *Ricania sp.*
- 231. *Cowbug*
- 232. *Froghopper*
- 233. *Lanternfly*
- 234. *Mealybug*
- 235. *Cicada*
- 236. *Leafhopper*

Mantodea

- 237. *Gongylus gongyloides*
- 238. *Empusa sp.*

- 239. *Euantissa* sp.
- 240. *Hierodula* sp
- 241. *Humbertiella* sp
- 242. *Schizocephala bicornis*

Phasmida

- 243. *Carausius* sp.

Blattodea

- 244. *Therea petiveriana*

Neuroptera

- 245. *Myrmileontidae*
- 246. *Ascalaphidae* sp
- 247. Green lacewing
- 248. Brown lacewing

Diptera

- 249. *Dolichopodidae* sp.
- 250. *Chrysops* sp.
- 251. *Bombylius* sp.
- 252. *Mesembrius quadrivittatus*
- 253. *Tabanus* sp.
- 254. Flesh fly
- 255. Blow fly
- 256. Robber fly
- 257. Crane fly
- 258. Hoverfly
- 259. Orthoptera

Orthoptera

Grasshoppers

- 260. *Acrida* sp
- 261. *Atractomorpha* sp.

- 262. *Aularches* sp
- 263. *Heiroyglyphus* sp.
- 264. *Neorthacris* sp.
- 265. *Teratodes monticollis*
- 266. *Poecilocera pictus*
- 267. *Spathosternum* sp.
- 268. *Oxyrrhypes* sp.
- 269. Grouse locust
- 270. Mole-cricket

Bushcrickets

- 271. Bush katydid
- 272. Snout-nosed katydid
- 273. Long-legged katydid
- 274. Cone headed katydid
- 275. *Mecopoda* sp

Odonata

Dragonflies

- 276. *Rhyothemis variegata*
- 277. *Crocothemis sevilla*
- 278. *Brachythermis contaminate*
- 279. *Neothermis* sp.
- 280. *Pantala flavescens*
- 281. *Diplocodes trivialis*
- 282. *Orthetrum sabina*

Damselflies

- 283. *Ceriagrion coramandelianum*
- 284. *Pseudagrion* sp.
- 285. *Agriocnemis pygmaea*

10. Check List of Plants

Given below is a list of plants with names of their families. These are plants on which the insects described in this book can be found. This is by no means an exhaustive list.

Botanical names	Family	Common name
1. <i>Abrus precatorius</i>	Fabaceae	Crab's eye
2. <i>Abutilon indicum</i>	Malvaceae	
3. <i>Acacia arabica</i>	Fabaceae (Mimosaceae)	Subabul
4. <i>Albizia amara</i>	Fabaceae (Mimosaceae)	Bitter albizia
5. <i>Albizia lebbek</i>	Fabaceae (Mimosaceae)	
6. <i>Anacardium occidentale</i>	Anacardiaceae	Cashew
7. <i>Annona squamosa</i>	Annonaceae	Custard apple
8. <i>Aristolochia indica</i>	Aristolochiaceae	
9. <i>Asclepias</i> sp.	Asclepiadaceae	
10. <i>Bambusa arundinacea</i>	Poaceae	
11. <i>Bambusa tulda</i>	Poaceae	Bamboo
12. <i>Barleria buxifolia</i>	Acanthaceae	
13. <i>Bougainvillea spectabilis</i>	Nyctaginaceae	
14. <i>Kalanchoe pinnata</i>	Crassulaceae	
15. <i>Butea monosperma</i>	Fabaceae	Flame of the forest
16. <i>Calotropis gigantea</i>	Asclepiadaceae	Indian madar
17. <i>Capparis brevispina</i>	Capparaceae	
18. <i>Cassia auriculata</i>	Fabaceae (Caesalpineaceae)	
19. <i>Cassia fistula</i>	Caesalpineae	Indian laburnum
20. <i>Cestrum diurnum</i>	Solanaceae	Day jasmine
21. <i>Cestrum nocturnum</i>	Solanaceae	Night queen
22. <i>Crotalaria biflora</i>	Fabaceae	
23. <i>Croton bonplandianum</i>	Euphorbiaceae	
24. <i>Cucumis sativus</i>	Cucurbitaceae	Cucumber
25. <i>Duranta erecta</i>	Verbenaceae	
26. <i>Eucalyptus lanceolatus</i>	Myrtaceae	
27. <i>Ficus bengalensis</i>	Moraceae	Banyan
28. <i>Ficus racemosa</i>	Moraceae	
29. <i>Ficus religiosa</i>	Moraceae	Peepul

30. <i>Gynandropsis pentaphylla</i>	Capparaceae	
31. <i>Indigofera</i> sp.	Fabaceae	
32. <i>Ipomea campanulata</i>	Convolvulaceae	
33. <i>Ixora elongata</i>	Rubiaceae	
34. <i>Jasminium officinale</i>	Oleaceae	White jasmine
35. <i>Justicia procumbens</i>	Acanthaceae	
36. <i>Kalanchoe laciniata</i>	Crassulaceae	
37. <i>Lantana indica</i>	Verbenaceae	
38. <i>Limonia acidissima</i>	Rutaceae	Lime family
39. <i>Loranthus</i> sp.	Loranthaceae	
40. <i>Mangifera indica</i>	Anacrdaceae	Mango
41. <i>Morus alba</i>	Moraceae	Mulberry
42. <i>Murraya koenigi</i>	Rutaceae	Curry leaf
43. <i>Nerium oleander</i>	Apocyanaceae	<i>Arali</i>
44. <i>Passiflora foetida</i>	Passifloraceae	Passion flower
45. <i>Peltophorum pterocarpum</i> (Caesalpineaceae)	Fabaceae	Rusty-shield bearer
46. <i>Petunia tuberosa</i>	Solanceae	
47. <i>Pongamia glabarata</i>	Fabaceae	
48. <i>Portulaca glabra</i>	Portulacaceae	
49. <i>Rhoea discolor</i>	Commelinaceae	
50. <i>Ricinus</i> sp.	Euphorbiaceae	Castor
51. <i>Sapindus trifoliata</i>	Sapindaceae	Soap nut
52. <i>Solanum melongena</i>	Solanaceae	Brinjal
53. <i>Solanum tuberosum</i>	Solanaceae	Potato
54. <i>Syzygium jambolanum</i>	Myrtaceae	Jamun
55. <i>Tabernaemontana coronaria</i>	Apocyanaceae	Moonbeam
56. <i>Tamarindus indica</i> (Caesalpineaceae)	Fabaceae	Tamarind
57. <i>Tecoma grandiflora</i>	Bignoniaceae	
58. <i>Tecoma stans</i>	Bignoniaceae	Yellow bells
59. <i>Tecomaria capensis</i>	Bignoniaceae	Cape honey suckle
60. <i>Thevetia neriifolia</i>	Apocyanaceae	
61. <i>Tradescantia</i> sp.	Commelinaceae	Wandering jew
62. <i>Tragia cannabina</i>	Euphorbiaceae	
63. <i>Tridax procumbens</i>	Asteraceae	
64. <i>Zizyphus jujuba</i>	Rhamnaceae	<i>Ber</i>

* Fabceae was earlier known as papilionaceae

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Rebecca Thomas
Geetha Iyer

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Ants of Sunil Peninsular India

Websites that you can use to learn more about insects:

<http://en.wikipedia.org/wiki/Orthoptera>
(all insect orders can be browsed at Wikipedia)
<http://www.earthlife.net/insects>.
<http://www.insects.org>
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<http://bugguide.net>
<http://www.ento.csiro.au>
<http://www.hymenopterists.org>
<http://www.blattodea.net/> (on cockroaches)
<http://www.angelfire.com/oh2/Roaches/>

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<http://tech.groups.yahoo.com/group/InsectIndia/> - Insects in general
<http://in.groups.yahoo.com/group/Indianmoths/> - Moths
<http://pets.groups.yahoo.com/group/ButterflyIndia/> - Butterflies
<http://tech.groups.yahoo.com/group/DragonflyIndia/> - Dragonflies & damselflies

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Ṣaṭpada means 'six-legged' in Sanskrit. As this word aptly highlights one of the features for identifying an insect — three pairs of legs — it was chosen as the title for this book. *Ṣaṭpada* Our World of Insects, gives a brief account of the insect world. It highlights select insect examples and gives tips and activities for those who hopefully will become interested in these fascinating creatures and distinguish themselves in the field of entomology.

